Assessment of Habitat and Biota in Tributaries of Big Creek and the South Fork Salmon River, Payette National Forest

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Dear Dr. Burns,

Enclosed you will find a copy of the 1996 Assessment of Habitat and Biota in Tributaries of Big Creek and the South Fork Salmon River, Payette National Forest report.

If you have any questions or comments please contact either Kate Bowman or Todd Royer at (208) 236-2139, or G. W. Minshall at (208) 236-2236.

Sincerely,

Kathryn Bowman

Kathryn Bowman

TABLE OF CONTENTS

LIST OF FIGURES.. ii

LIST OF TABLES.. iii

SUMMARY.. 1

INTRODUCTION.. 2

STUDY SITE DESCRIPTIONS.. 2

METHODS.. 3

RESULTS.. 7

Big Creek tributaries.. 7

South Fork of the Salmon R. tributaries.. 30

DISCUSSION.. 40

ACKNOWLEDGMENTS.. 43

LITERATURE CITED.. 44

LIST OF FIGURES

Figure 1. Periphyton chl *a* from the Big Creek tributaries.. 10

Figure 2. Periphyton AFDM from the Big Creek tributaries.................................... 12

Figure 3. Thermal regime for Upper Cliff Creek.. 16

Figure 4. Thermal regime for Lower Cliff Creek.. 17

Figure 5. Thermal regime for Pioneer Creek... 18

Figure 6. Thermal regime for Cougar Creek.. 19

Figure 7. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Rush Creek.. 20

Figure 8. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Pioneer Creek.. 21

Figure 9. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cave Creek.. 22

Figure 10. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cliff Creek.. 24

Figure 11. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cougar Creek.. 25

Figure 12. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Goat Creek.. 26

Figure 13. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Upper Cliff Creek.. 28

Figure 14. Periphyton chl *a* and AFDM for the South Fork Salmon R. tributaries.. 32

Figure 15. Macroinvertebrate density and biomass for the South Fork Salmon R. tributaries.. 33

Figure 16. Macroinvertebrate taxa richness and Simpson's Index for the South Fork Salmon R. tributaries... 34

LIST OF TABLES

Table 1. Location and description of study streams.......... 4

Table 2. Summary of variables, methods, and procedures.......... 5

Table 3. Discharge and chemical measures for the Big Creek tributaries.......... 8

Table 4. Habitat heterogeneity measures for the Big Creek tributaries.......... 9

Table 5. Chemical and benthic habitat variables measured in Upper Cliff Creek.......... 14

Table 6. Relative abundance of the 15 most common macro-invertebrate taxa in the Big Creek tributaries.......... 27

Table 7. Relative abundance of the 15 most common macro-invertebrate taxa in Upper Cliff Creek.......... 29

Table 8. Chemical and benthic habitat variables measured in the South Fork of the Salmon R. tributaries.......... 31

Table 9. Relative abundance of the 15 most common macroinvertebrate taxa in the South Fork of the Salmon R. tributaries.......... 35

Table 10. Macroinvertebrate taxa list for K Creek.......... 36

Table 11. Macroinvertebrate taxa list for Big Flat Creek.......... 38

SUMMARY

This report presents the results of our research conducted for the Payette National Forest during 1996. As in the past, our research was conducted on two groups of streams: (1) tributaries to Big Creek inside the Frank Church Wilderness Area, and (2) tributaries to the South Fork of the Salmon River immediately west of the wilderness area. These streams have been influenced by various wildfires since 1988. The effect of wildfires on stream ecosystems has been the focus of our research over the past several years (see Royer et al. 1995, Royer and Minshall 1996).

In general, no substantial changes in water chemistry of the streams have been observed in the tributaries to Big Creek. Similarly, measurements of physical habitat characteristics have not displayed any consitent pattern over the course of the study. The heavy spring runoff in 1996 did not appear to scour the streams to any great extent. It appears that the Golden Fire has not, to date, been a major influence on the physical and chemical habitat of Cliff, Cougar, or Goat Creeks. Similarly, the Chicken Fire has not created unstable habitat conditions in Fritser Creek. Data loggers were used to measure water temperature in Cliff, Upper Cliff, Pioneer, and Cougar Creeks. Temperature patterns in the burned streams did not appear to have been influenced by the Golden Fire. Overall, the physical and chemical habitat of the study streams has not been altered by either the Golden Fire or the Chicken Fire.

The collection of baseline data and the description of natural variation in ecological conditions is a major goal of this research. In this regard, macroinvertebrate density and taxa richness appear to be useful metrics for describing the natural variation in the structure of macroinvertebrate communities in these streams. The several years of data from Cliff, Rush, Pioneer, and Cougar Creeks indicates that relatively stable long-term means exist for both density and taxa richness. The severity of future disturbances may be determined by examining changes in the denstiy and/or number of taxa, relative to the long-term mean in a given stream.

INTRODUCTION

Our primary research goal during 1996 was to continue monitoring tributaries to Big Creek and the South Fork of the Salmon River (S.F. Salmon) that we had examined in previous years. These streams have been examined in relation to the role of wildfire in structuring benthic habitat and invertebrate communities in the Payette National Forest (Royer and Minshall 1996, Royer et al. 1995). The studies in the Big Creek catchment were designed to examine the influence of the 1988 Golden Fire, while those in the S.F. Salmon catchment examined the 1994 Chicken Fire. To date, the effects of these wildfires on stream invertebrate communities have appeared ambiguous, with no clear and discernable patterns emerging over several years of study. Royer and Minshall (1996) suggested that the influence of the wildfires may be more pronounced following the melting of the heavy snowpack of 1995-1996. This will be specifically examined in the current report.

For all streams examined, the results provide baseline habitat and macroinvertebrate data against which the effects of future disturbances (natural or anthropogenic) can be measured. This was the goal of our work on Tailholt and Circle End Creeks, where an experimental timber harvest has been planned for Tailholt (USFS 1995). However, the timber harvest, originally scheduled for autumn 1996, was delayed, thereby providing another year of baseline data on that system. An additional component was added to the study in 1996: examining the effects of salvage logging on streams along the lower portion of the S.F. Salmon. Specifically, we surveyed several streams within the Big Flat Creek timber sale (Big Flat Creek, Little Flat Creek, China Creek, and K Creek). Smith Creek, adjacent to the timber sale, also was sampled and will serve as a reference for the other streams. These streams were sampled just prior to the onset of the salvage logging, thereby providing a "pre-logging" data set for all sites.

STUDY SITE DESCRIPTIONS

The study streams were located within the Payette National Forest in central Idaho either (1) along Big Creek in the Frank Church 'River of No Return' Wilderness Area or (2) along the

South Fork of the Salmon River just outside the wilderness area (Table 1). In both catchments, the streams flow through steep valleys with forested slopes of primarily Douglas Fir and Ponderosa Pine, also present are extensive areas of bare or sparsely vegetated rock. Open areas of grass and sagebrush are common on the drier slopes in both catchments. The majority of the annual precipitation occurs as snow, resulting in peak flows from late spring through mid-summer. The streams generally remain at baseflow conditions from late summer through autumn.

Study streams in the Big Creek catchment were influenced, to varying degrees, by either the Golden Fire of 1988 or the Rush Point Fire of 1991. The upper portions of the Cliff and Cougar were affected by the Golden Fire; Goat Creek was not burned by the wildfire, but rather by an intentional "back-burn". Cave Creek serves as a reference for these sites. All of the above streams have a southern aspect. The upper portion of the Rush and Pioneer Creek catchments were minimally influenced by the Rush Point Fire and have northern aspects. Thus they provide a comparison with the south-facing streams listed above. In the S.F. Salmon catchment, Fritser Creek was moderately burned during the Chicken Fire of 1994. Tailholt and Circle End were not affected by the Chicken Fire. All of the S.F. Salmon tributaries we examined had a southeastern aspect. The streams in the salvage logging study were burned by the Chicken Fire in 1994 and subsequently logged in late summer 1996. The reference site, Smith Creek, was considerably larger than any of the logged streams, but provided the only accessible reference stream in the immediate area, due to numerous road closures related to the logging activities.

METHODS

Field methods used for the various segments of this study are summarized in Table 2. The methods were consistent with methods used in our previous studies of wildfire and wilderness streams. These are relatively routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Stednik 1991, Merritt and Cummins 1996, APHA 1992, Platts et al. 1983, Davis et al. *in review*) or in more specific references listed in Table 2. Mean substratum size, water depths, and embeddedness were

Table 1. Location of the study streams in the Big Creek and South Fork of the Salmon River catchments.

Stream	Elevation (m)	Longitude	Latitude	Township	Range
Big Creek Catchment					
Rush Creek	1170	114° 51'W	45° 07'N	T20N	R13E
Pioneer Creek	1170	114° 51'W	45° 06'N	T20N	R13E
Cave Creek	1220	114° 57'W	45° 08'N	T21N	R12E
Cliff Creek (upper)	1680	114° 51'W	45° 08'N	T20N	R13E
Cliff Creek (lower)	1200	114° 51'W	45° 07'N	T20N	R13E
Goat Creek	1130	114° 48'W	45° 07'N	T20N	R13E
Cougar Creek	1100	114° 49'W	45° 07'N	T20N	R13E
S. F. Salmon Catchment					
Circle End Creek	1110	115° 39'W	45° 2'N	T20N	R06E
Tailholt Creek	1110	115° 39'W	45° 2'N	T20N	R06E
Fritser Creek	1036	115° 38'W	45° 5'N	T20N	R07E
Smith Creek	914	115° 31'W	45° 14'N	T22N	R07E
Little Flat Creek	914	115° 32'W	45° 13'N	T22N	R06E
Big Flat Creek	914	115° 33'W	45° 13'N	T22N	R06E
China Creek	914	115° 34'W	45° 12'N	T22N	R06E
K Creek	914	115° 34'W	45° 12'N	T22N	R06E

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method	Reference
A. Physical				
Temperature	P	Continuous measurement with a datalogger	Calculate temp. indices	
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size	Bevenger and King 1995
Substratum Embed-dedness	R	Visual estimation on 100 randomly selected substrata	Calculate mean substratum embeddedness	Platts et al. 1983
Stream Width	T	Measure bank-full width using a nylon meter tape	Calculate mean stream width	Buchanan and Somers 1969
Stream Depth	R	Measure water depth at the 100 randomly chosen substrata	Calculate mean water depth	
Discharge	T	Velocity/depth profile Velocity measured with a small C-1 Ott meter	Q=WxDxV; where Q=discharge, W=width, D=depth, and V=vel	Bovee and Milhous 1978
B. Chemical				
Conductivity	P	Field measurement	Temperature comp-ensated meter (Orion model 126)	APHA 1992

* P=point measure; T=transect across stream; R=random throughout a defined reach.

Table 2 (cont.).

Variable	Type*	Sampling Method	Analytical Method	Reference
pH	P	Field measurement	Digital meter (Orion model 250/A)	APHA 1992
Alkalinity	P	Single water sample	Methly-purple titration	APHA 1992
Hardness	P	Single water sample	EDTA titration	APHA 1992
C. Biological				
Invertebrates	R	Collect 5 samples using a Surber sampler	Remove invertebrates, identify, enumerate, and analyze community properties	Platts et al. 1983, Merritt and Cummins 1995
Periphyton	R	Collect samples from 5 individual substrata	Methanol extraction	Robinson and Minshall 1986

* P=point measure; T=transect across stream; R=random throughout a defined reach.

determined at 100 random locations along a substantial (ca. 200 meter) reach of stream. Procedures for sample analysis are described briefly in Table 2. Density, biomass, taxa richness, and Simpson's Index were determined for the macroinvertebrate communities for all sites and years.

RESULTS

Big Creek Tributaries

In general, no substantial changes in water chemistry of the streams have been observed (Table 3). Similarly, the measurements of physical habitat in the streams have not varied in any consistent manner over the course of the study (Table 4). The heavy runoff that occurred during the spring and early summer of 1996 may have scoured the streams and altered benthic habitat, but evidence of this is sparse. For example, both Cliff and Cougar displayed greater mean stream width and reduced stream depth from 1995 to 1996 (Table 4). This suggests the flooding created a wider, shallower channel at these sites. However, neither Cliff nor Cougar showed a change in substrate size or embeddedness, as would be expected following a major flood event.

Mean values of chlorophyll-a were unchanged in Rush and Cave Creeks between 1995 and 1996 (Fig. 1). Pioneer Creek showed a marked decrease in mean chlorophyll-a from 1995 to 1996, although the 1995 samples were highly variable (Fig. 1). Cliff and Cougar Creeks both displayed reduced chlorophyll-a (Fig. 1) and periphyton AFDM (Fig. 2) from 1995 to 1996, suggesting that high flows had decreased algal standing crops. In Goat Creek, an increase in algal abundance was measured from 1995 to 1996, but the variability within the replicate samples was large (Figs. 1 and 2). In general, no consistent pattern in periphyton chlorophyll-a or AFDM has been observed among the study streams in relation to wildfire.

Water chemistry in Upper Cliff Creek was generally similar to previous years (Table 5). A substantial decrease in substrate embeddedness was measured between 1995 and 1996, possibly indicating scouring flows. However, mean substrate size also decreased over the same period suggesting sediment deposition, rather than scouring (Table 5). Periphyton AFDM was unchanged from 1995 to 1996, whereas chlorophyll-a increased by an order of magnitude.

Table 3. Discharge and chemical measures for the study streams in the Big Creek catchment.

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)	pH
Rush	1988	1.61	36	30	110	7.8
	1991				103	8.2
	1992	1.10	46	46	95	8.4
	1993	0.31				7.9
	1994	1.56			77	
	1995	1.75	32	57	76	8.2
	1996	1.59	36	80	99	8.5
Pioneer	1990	0.16	62	86	88	8.1
	1991	0.01			125	8.0
	1993	0.02	26	48	72	
	1994	0.17			113	
	1995	0.21	42	81	135	7.9
	1996	0.11	40	70	119	7.7
Cave	1990	0.31	24	44	39	7.9
	1993	0.08	19	24	55	
	1994	0.21				
	1995	0.17	20	40	48	8.1
	1996	0.22	44	48	66	7.8
Cliff	1990	0.32	35	66	61	8.2
	1991	0.18	77	71	73	8.2
	1992	0.08	48	49	99	8.0
	1993	0.09	26	44	77	7.7
	1994	0.10			79	
	1995	0.15	34	53	93	8.2
	1996	0.14	32	42	105	7.3
Goat	1990	0.01	86	110	139	8.1
	1991	0.09	49	51	153	8.4
	1992	0.01	80	76	151	8.2
	1993	0.01	41	68	116	8.1
	1994	0.01			148	
	1995	0.01	56	93	140	8.1
	1996	0.04	50	68	157	8
Cougar	1990	0.11	46	71	70	8.5
	1991	0.10	36	32	93	7.4
	1992	0.01	59	60	113	8.2
	1993	0.02	33	48	94	7.7
	1994	0.08				
	1995	0.10	48	85	107	8.2
	1996	0.15	52	80	158	8.2

Table 4. Habitat heterogeneity measures for study streams in the Big Creek catchment. SD = standard deviation, CV = coefficient of variation.

		Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Rush	1988	14.6	14.0	0.96				15.1		35.0	10.0
	1992	13.3	9.2	0.69	18.8	26.7	0.96	12.0		21.0	10.0
	1993	21.3	14.8	0.69	35.0	28.9	0.51	13.4	1.5	26.2	7.3
	1994	13.9	13.2	0.95	39.3	34.0	0.46	6.3	4.8	26.2	7.9
	1995	22.6	16.7	0.74	25.0	26.2	1.05	11.8	0.6	35.0	10.3
	1996	21.0	20.0	0.95	30.0	36.0	1.20	13.9	2.4	25.4	15.0
Pioneer	1990	16.7	14.0	0.84	12.5	23.9	1.44	3.4		16.0	4.5
	1993	19.5	18.7	0.96	33.8	28.8	0.53	2.9	0.9	15.3	7.7
	1994	13.9	15.2	1.09	34.3	33.7	0.53	1.7	4.2	18.0	7.9
	1995	15.2	17.4	1.14	45.3	36.3	0.80	3.0	0.6	17.5	10.1
	1996	17.0	20.0	1.18	44.0	40.0	0.91	2.7	0.5	14.7	9.3
Cave	1990	18.8	12.2	0.65				6.1		15.0	6.0
	1993	18.2	17.0	0.93	59.8	29.8	0.30	5.4	0.5	15.3	8.1
	1994	18.3	15.9	0.87	45.0	33.9	0.40	4.1	8.1	15.6	9.5
	1995	15.1	18.7	1.24	56.5	33.1	0.59	5.2	1.2	18.8	7.9
	1996	16.0	11.0	0.69	14.0	21.0	1.50	5.0	0.8	15.7	9.7
Cliff	1990	25.3	17.7	0.70				3.5		20.0	4.0
	1991	22.5	20.3	0.90				3.8		20.0	8.0
	1992	26.8	26.8	1.00				5.5		20.0	14.0
	1993	21.5	16.8	0.78	41.8	31.6	0.43	3.2	0.7	16.4	8.3
	1994	19.5	16.3	0.84	40.9	30.8	0.44	2.0	6.4	20.9	10.2
	1995	21.5	24.4	1.13	66.0	73.4	1.11	3.5	0.7	22.1	10.7
	1996	21.0	27.0	1.29	41.0	39.0	0.95	4.2	1.5	11.1	8.1
Goat	1990	9.7	16.5	1.70				0.9		10.0	2.0
	1991	10.9	16.4	1.50				0.9		10.0	3.0
	1992	13.1	17.0	1.30				0.8		10.0	7.0
	1993	17.5	16.6	0.95	43.8	35.4	0.41	1.1	0.3	12.0	4.1
	1994	11.7	16.1	1.38	68.5	31.1	0.26	0.9	0.2	10.4	4.4
	1995	12.0	14.0	1.16	65.3	34.5	0.53	1.2	0.3	10.8	5.7
	1996	24.0	27.0	1.13	55.0	37.0	0.67	1.3	0.2	5.9	4.1
Cougar	1990	21.6	13.0	0.60				2.7		20.0	
	1991	22.6	27.1	1.20				3.1		20.0	6.0
	1992	13.0	14.3	1.10				2.6		20.0	20.0
	1993	21.1	20.9	0.99	42.5	30.5	0.42	2.5	0.9	16.3	8.1
	1994	15.5	11.9	0.77	50.3	33.8	0.36	1.6	0.7	18.8	10.3
	1995	19.2	17.1	0.89	47.5	31.5	0.66	2.5	0.6	20.3	11.3
	1996	20.0	24.0	1.20	46.0	39.0	0.85	2.8	0.5	12.7	8.0

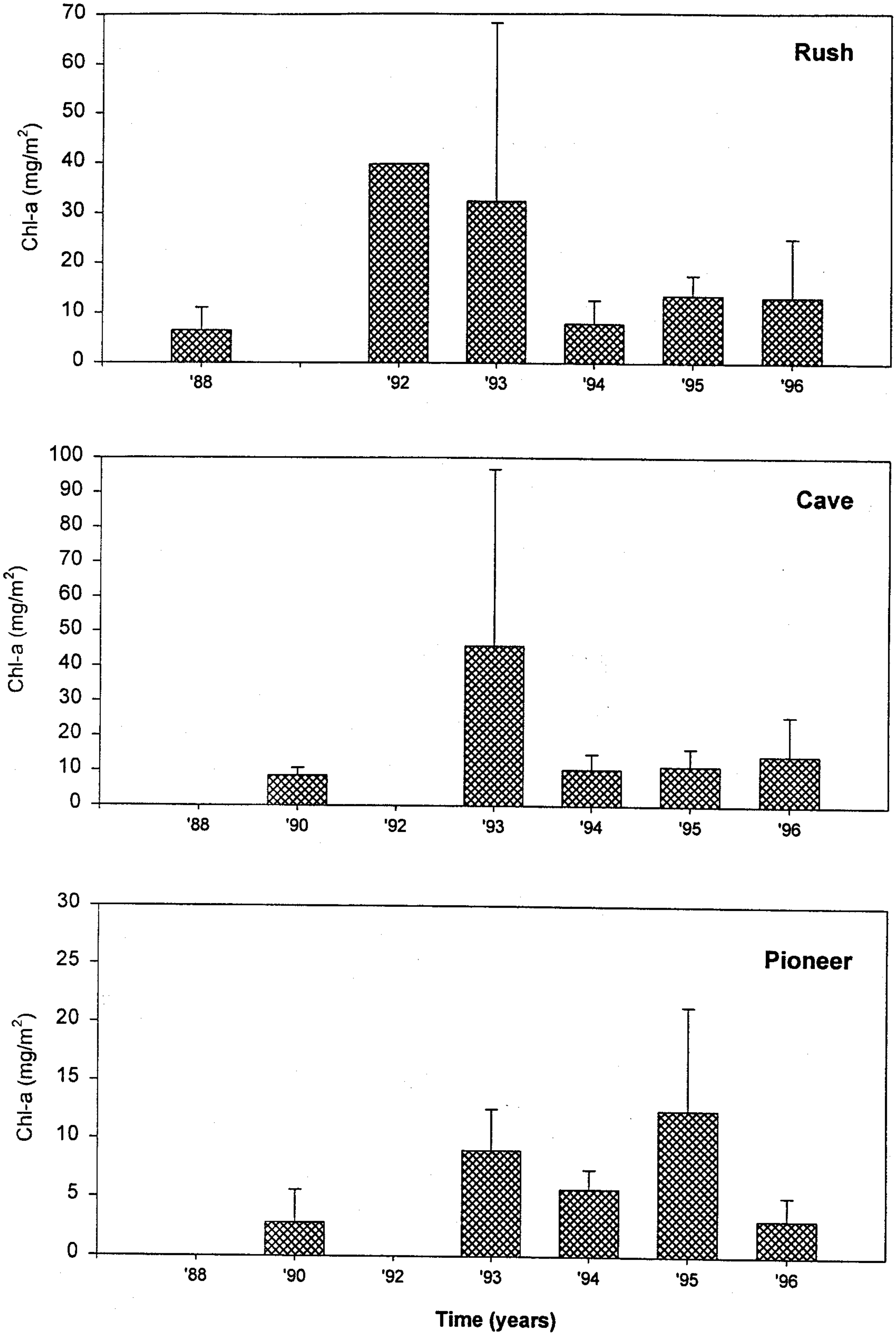


Figure 1. Mean values of periphyton chlorophyll *a* for the study streams. Error bars equal +1SD from the mean, n=5. Note the different scales on the y axis.

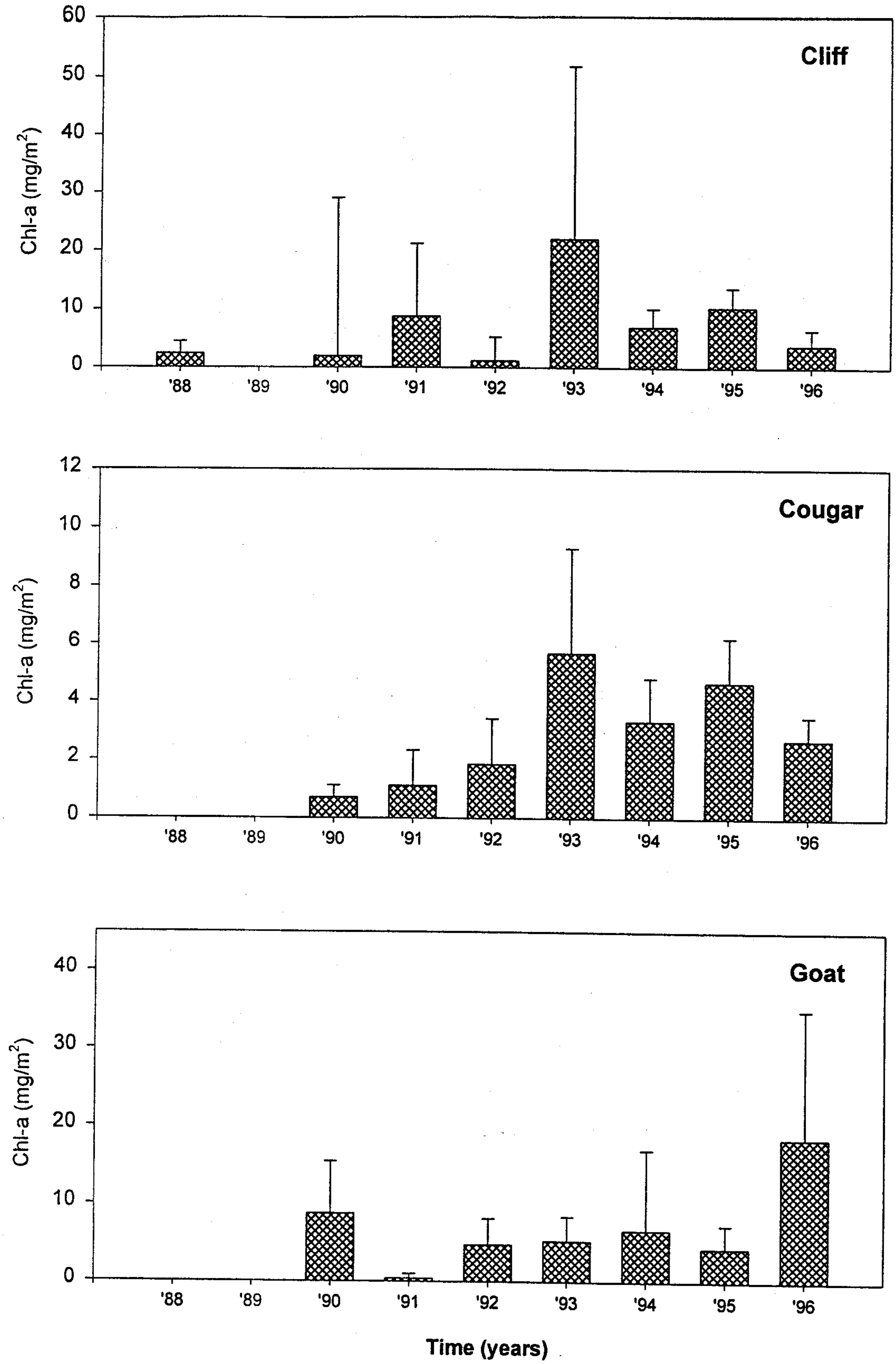


Figure 1 continued.

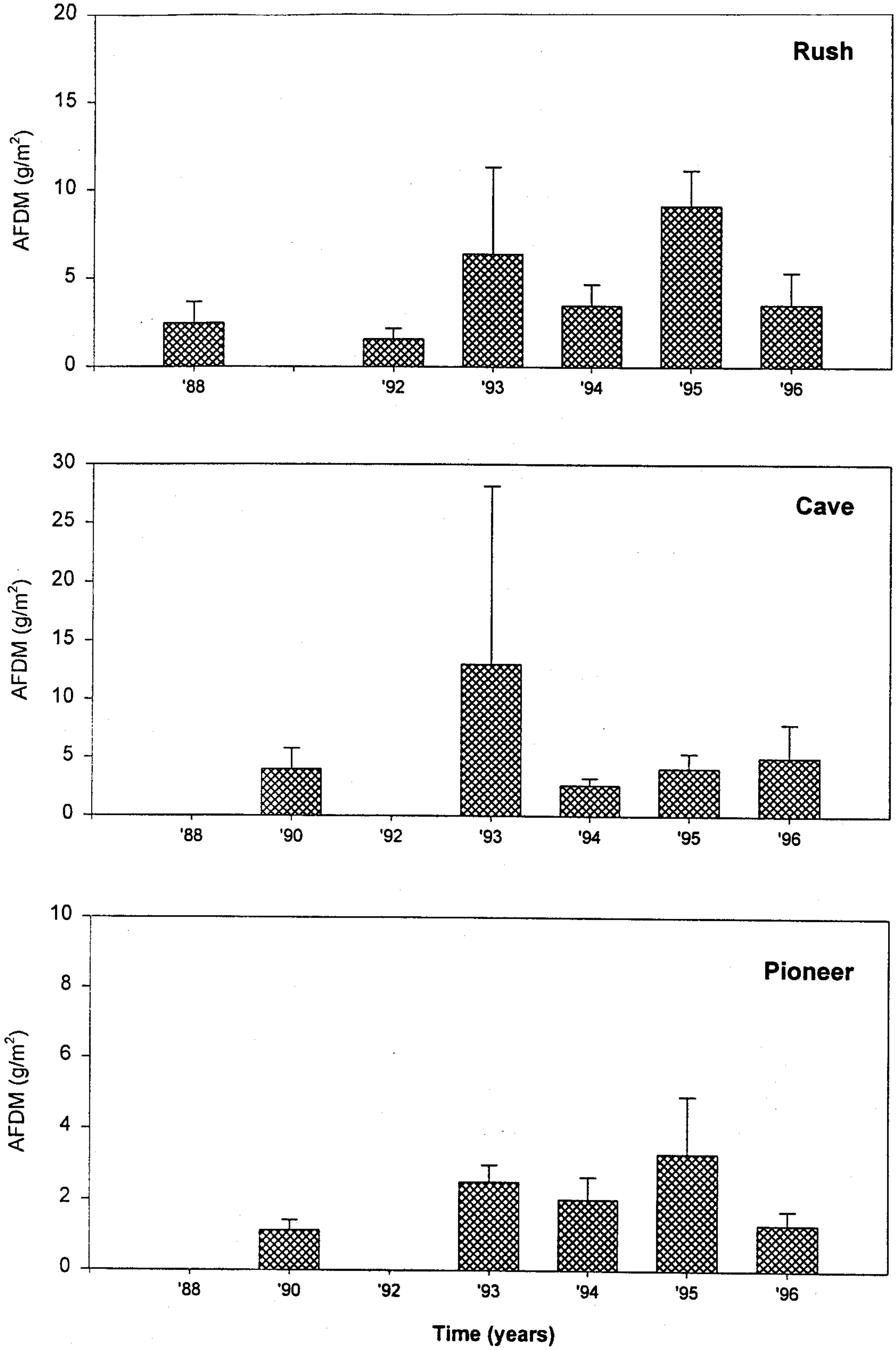


Figure 2. Mean values of periphyton ash-free dry mass (AFDM) for the study streams. Error bars equal +1SD from the mean, n=5. Note the different scales on the y axis.

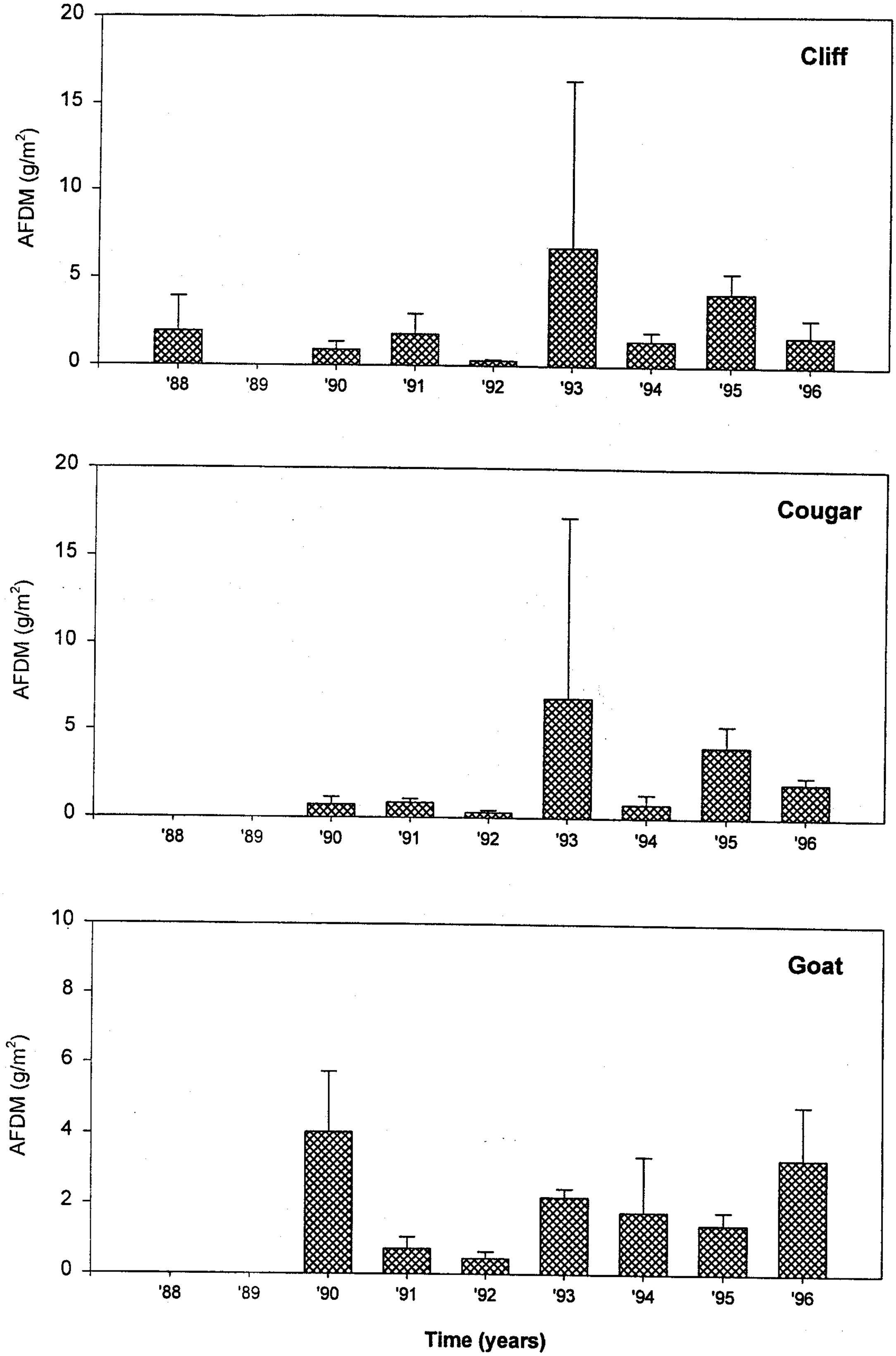


Figure 2 continued.

Table 5. Chemical and benthic habitat variables measured in Upper Cliff Creek, 1994-1996. SD=one standard deviation from the mean.

Discharge (m3/s)		
1994	0.06	
1995	0.14	
1996	0.09	
Specific Cond. (uS/cm @ 20C)		
1994	47	
1995	--	
1996	47	
Alkalinity (mg CaCO3/L)		
1995	16	
1996	22	
Hardness (mg CaCO3/L)		
1995	40	
1996	28	
	mean	SD
Periphyton Chl-a (mg/m2)		
1994	3.2	0.9
1995	0.7	0.5
1996	8.8	3.2
Periphyton AFDM (g/m2)		
1994	1.4	0.4
1995	4.0	3.9
1996	4.0	0.8
Substrata Size (cm)		
1994	21	14
1995	26	28
1996	16	12
Substrata Embeddedness (%)		
1994	37	25
1995	73	96
1996	13	22
Stream Width (m)		
1994	2.7	2
1995	4.4	0.7
1996	3.6	0.8

The thermal regime of Upper Cliff Creek is presented in Figure 3. The stream accumulated 1,051 degree days between 01 August 1995 and 30 June 1996. Maximum temperature was 13 °C and was recorded during late August. Diel temperature range peaked in June at approximately 5.5 °C. Lower Cliff Creek accumulated 1,916 degree days from 01 August 1995 through 27 July 1996 (Fig. 4). Maximum diel temperature change in Lower Cliff also occurred in June with values of approximately 5 °C. Lower Cliff Creek was warmer (by approx. 800 degree days) than the heavily burned Upper Cliff site. This was unexpected, as the open canopy at the Upper Cliff site was hypothesized to allow more solar radiation to reach the stream than would occur at the closed-canopy Lower Cliff site. The relative contribution of groundwater between the two sites may explain this result, although this was not measured.

The thermal regimes for Pioneer and Cougar Creeks are presented in Figures 5 and 6. (The recorder placed in Rush Creek was lost.) In general, Pioneer and Cougar displayed the same temperature patterns, although the actual values were greater in Cougar. For all the sites measured, maximum daily temperatures rarely exceeded 14-15 °C and mean daily temperatures exceeded 12 °C only in Cougar Creek, the warmest of the streams measured.

Aquatic macroinvertebrate density in Rush Creek was slightly greater in 1996 than in 1995 (Fig. 7). For the past four years (1993-96), density in Rush has ranged from approximately 5,000-9,000 individuals per square meter. Biomass has shown a much more variable pattern, both over time and within replicate samples. Over the entire course of the study, taxa richness in Rush has remained stable with mean values of 25-30 taxa. Simpson's Index, which takes into account the relative abundance of individual taxa, has been more variable over time than has taxa richness (Fig. 7). Density in Pioneer Creek increased from <3,500 individuals per square meter during 1993-95 to approximately 10,000 individuals per square meter in 1996 (Fig. 8). Biomass and taxa richness also showed increases from 1995 to 1996 in Pioneer. Greater than 30 taxa were identified in Pioneer in 1996, whereas mean taxa richness ranged from 15-20 during 1993-95. Density in Cave Creek was >10,000 individuals per square meter in 1996, approximately twice as large as the values measured from 1993-95 (Fig. 9). Despite the doubling of invertebrate density, biomass was unchanged from 1995 to 1996. As with Rush and Pioneer, Cave showed an increase in both taxa richness and Simpson's Index from 1995 to 1996.

Density in Cliff Creek increased from approximately 3,000 individuals per square meter

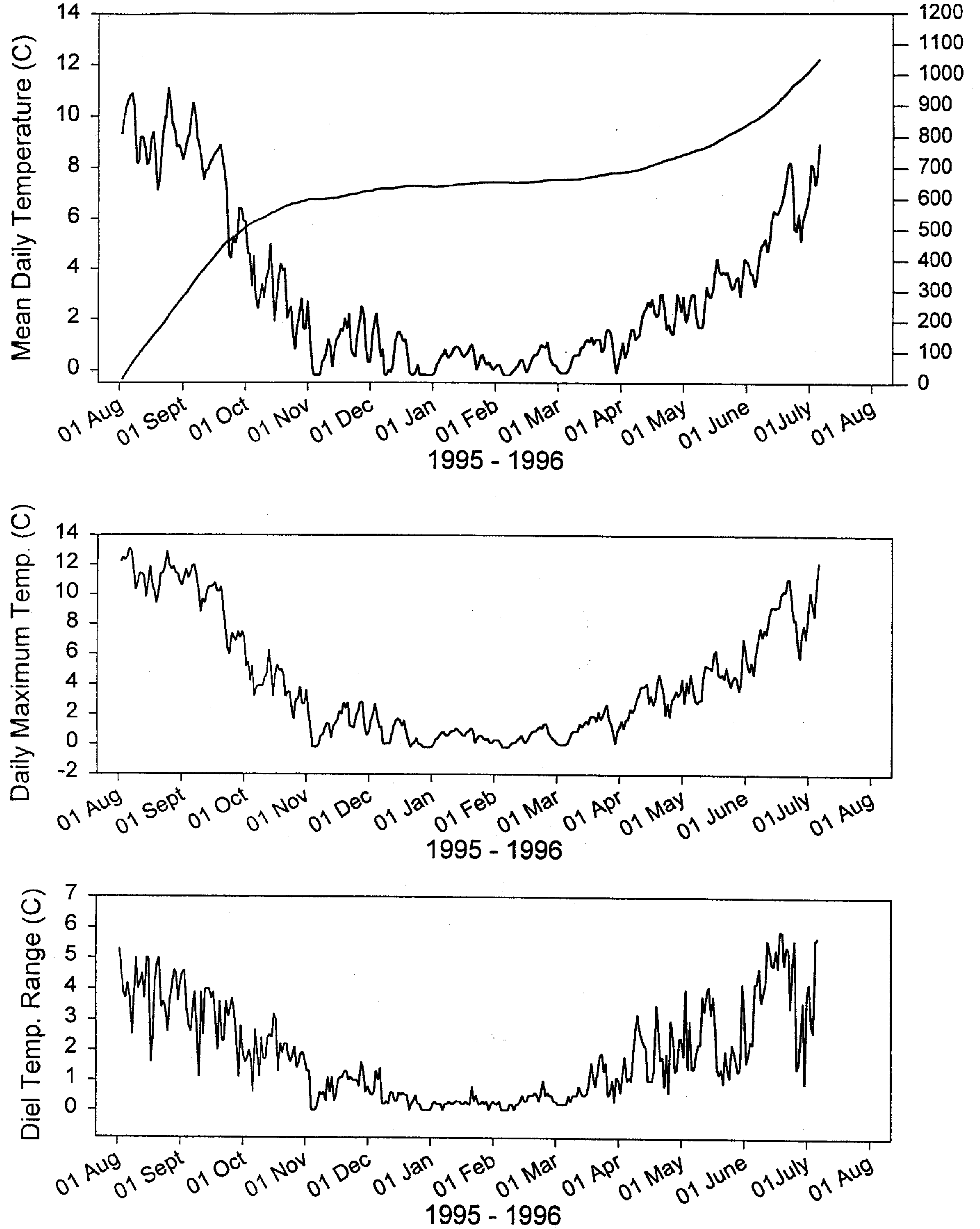


Figure 3 . Thermal regime for Upper Cliff Creek from August 1995 through July 1996.

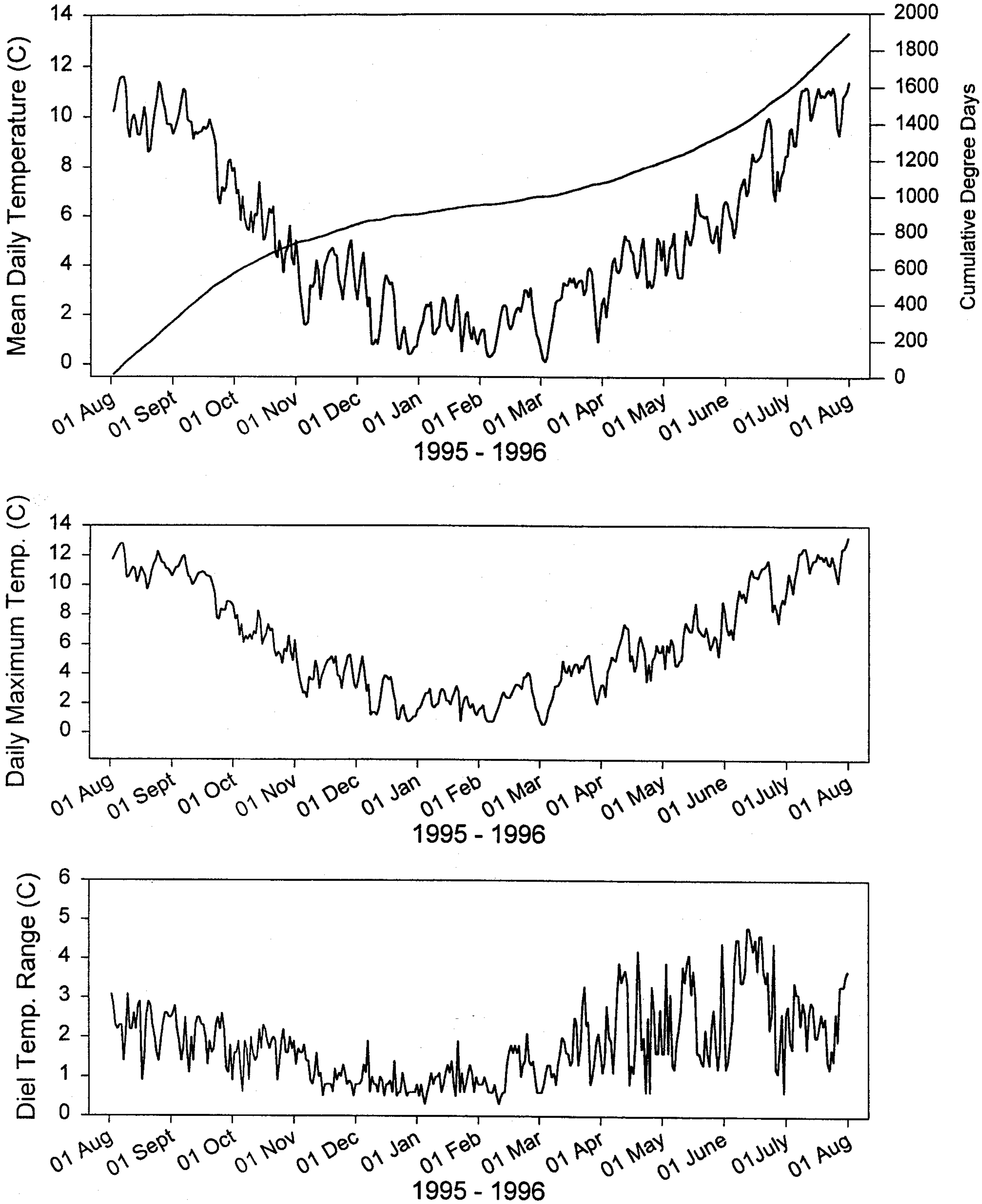


Figure 4 . Thermal regime for Lower Cliff Creek from August 1995 through July 1996.

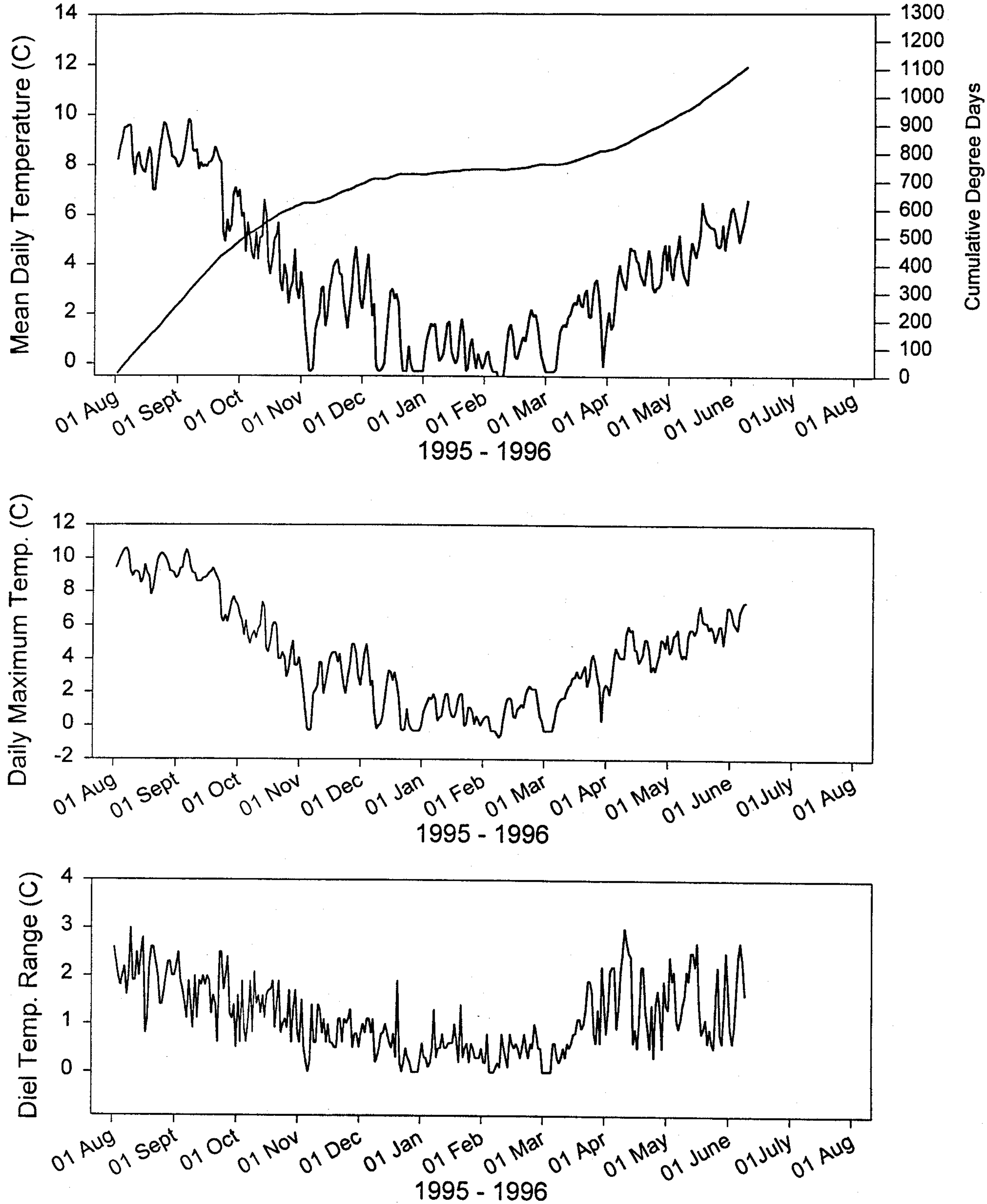


Figure 5. Thermal regime for Pioneer Creek from August 1995 through June 1996.

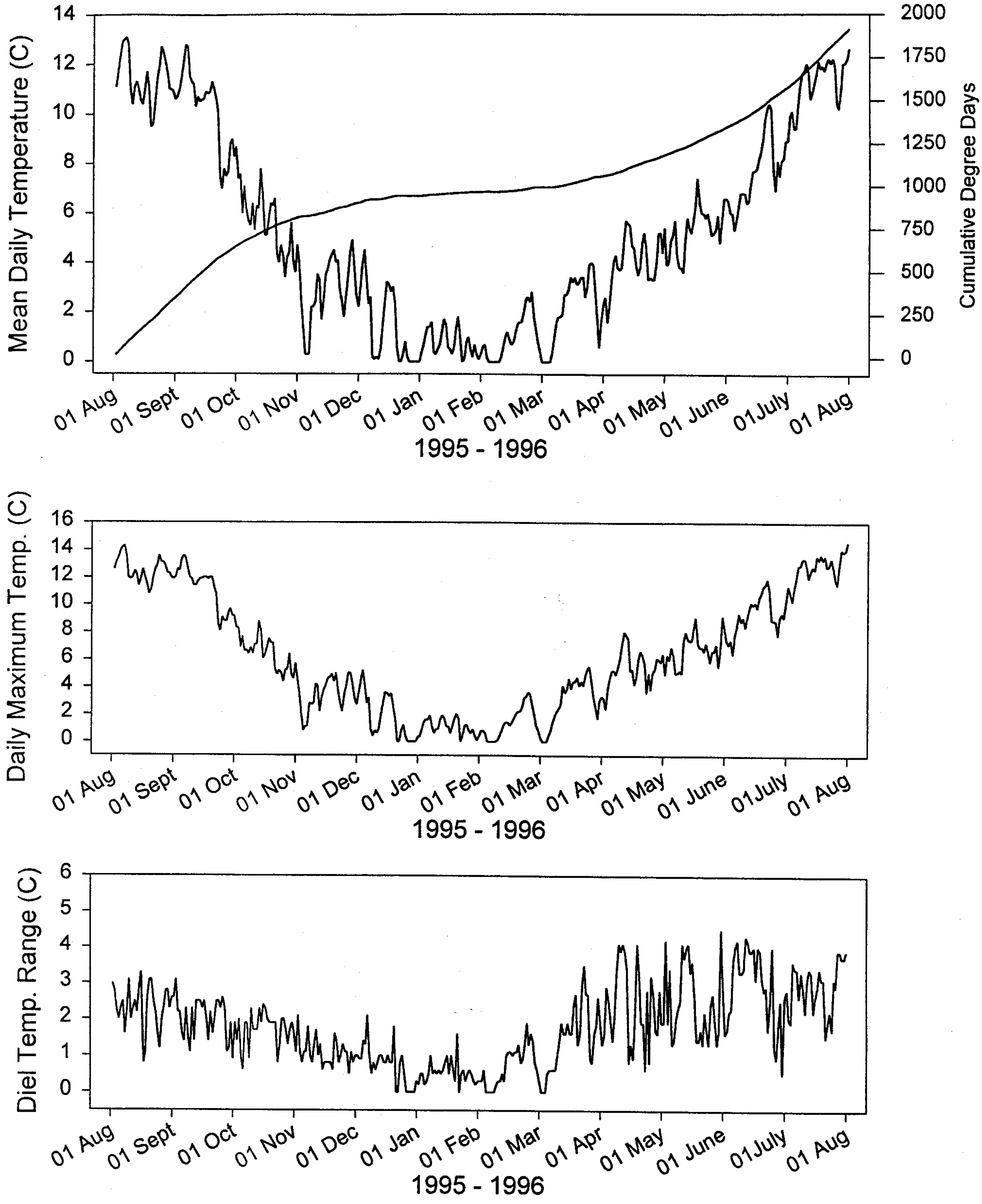


Figure 6. Thermal regime for Cougar Creek from August 1995 through July 1996.

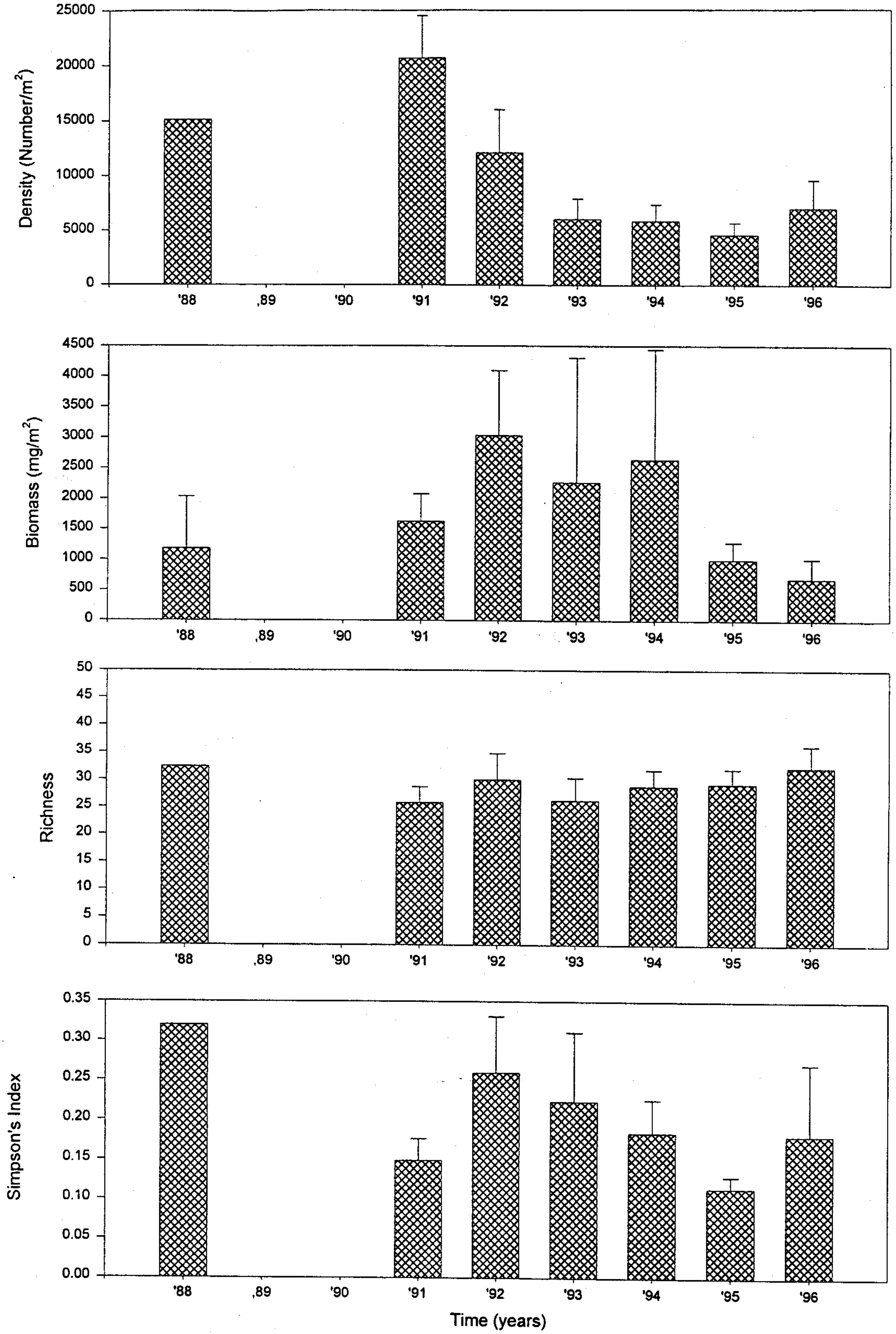


Figure 7. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Rush Creek. Error bars equal +1SD from the mean, n=5.

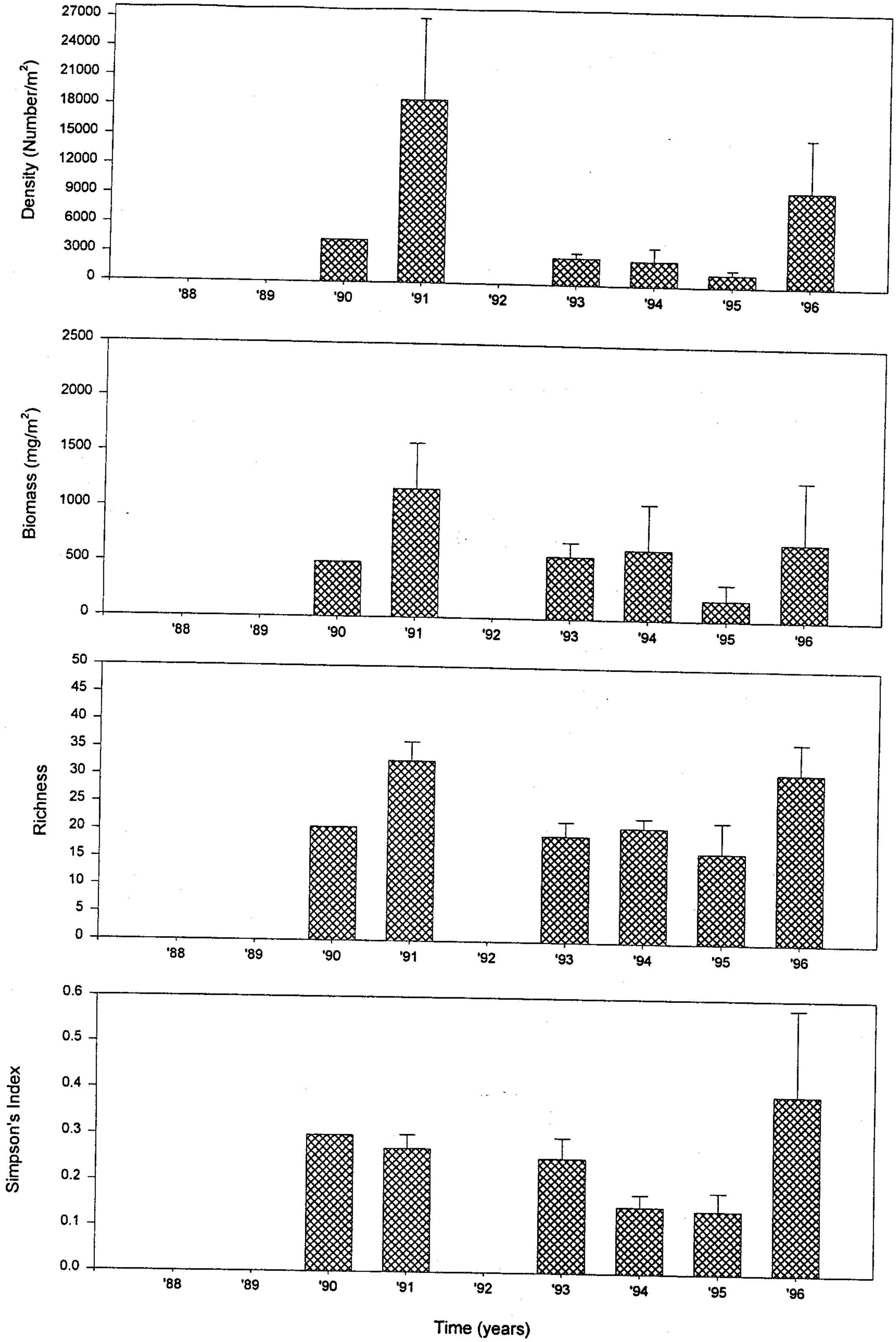


Figure 8. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Pioneer Creek. Error bars equal +1SD from the mean, n=5.

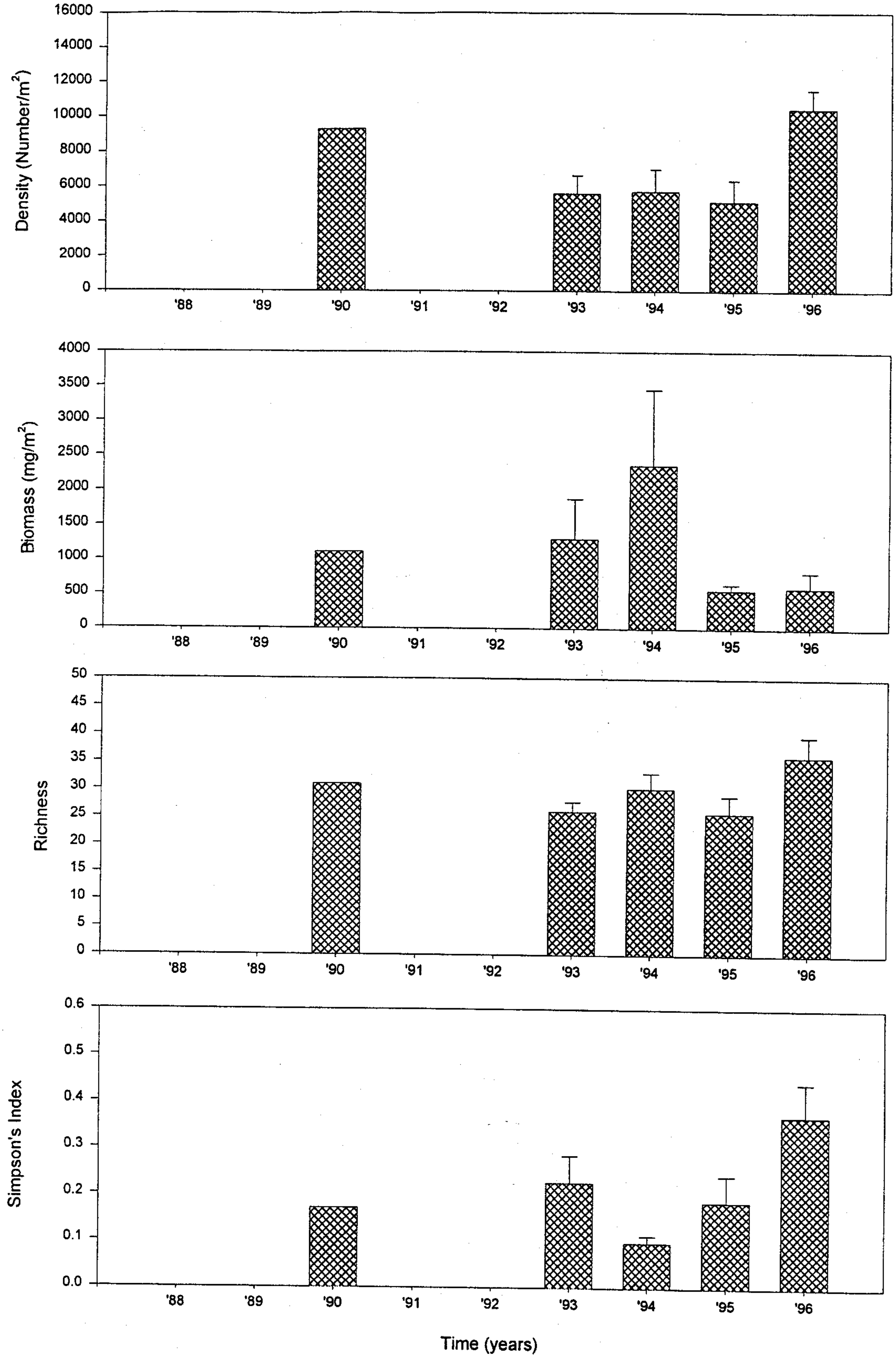


Figure 9. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cave Creek. Error bars equal +1SD from the mean, n=5.

in 1995 to approximately 5,000 in 1996. However, this amount of year-to-year change has been observed in Cliff since the outset of the study in 1988 (Fig. 10). Biomass also has remained relatively stable over the course of the study. Mean taxa richness has ranged from a low value of approximately 20 taxa in 1993 to a high of 30 in 1996. Simpson's Index has been the most variable of the community measures, although the values have been low (= high diversity) throughout the study (Fig. 10). Mean density and biomass in Cougar did not differ substantially in 1996 from the previous three years (Fig. 11). Mean taxa richness increased from approximately 20 taxa in 1995 to just over 30 in 1996; approximately 30 taxa were also found in 1992 and 1994. As with Cliff Creek, Simpson's Index in Cougar has been variable but with consistently low values. Goat Creek has typically displayed the lowest invertebrate density, biomass, and diversity of any of the streams sampled. Density in Goat did not change from 1995 to 1996, with a mean value of approximately 1,000 individuals per square meter (Fig. 12). Mean biomass declined from approximately 400 mg per square meter in 1995 to only 100 in 1996. Taxa richness in Goat during 1996 was unchanged from previous years at about 15 taxa (Fig. 12)

The relative abundance of the 15 most common invertebrate taxa in each stream are given in Table 6. The relative abundance of the most dominant taxon ranged from 25% in Rush Creek to 58% in Cave Creek. During 1996, Oligochaeta was the most abundant taxon in all streams except Goat Creek, where Chironomidae were dominant (31%). Other common taxa in 1996 included *Rhithrogena*, *Heterlimnius*, *Baetis*, and Hydracarina. In general, the taxa which constitute the majority of the invertebrate community have not changed substantially over the past 2-3 years (see Royer and Minshall 1996, Royer et al. 1995).

At the Upper Cliff Creek site, invertebrate density has declined from approximately 6,000 individuals per square meter in 1994 to >2,000 in 1996 (Fig 13). Biomass has shown a similar pattern as density. Mean taxa richness has remained steady at approximately 20-25 taxa over the three years of sampling, while Simpson's Index has been variable but always below 0.30 (Fig. 13). The most abundant taxa found in Upper Cliff Creek are shown in Table 7. Oligochaeta, Chironomidae, and *Baetis* have consistently been the most common taxa in Upper Cliff from 1994-1996.

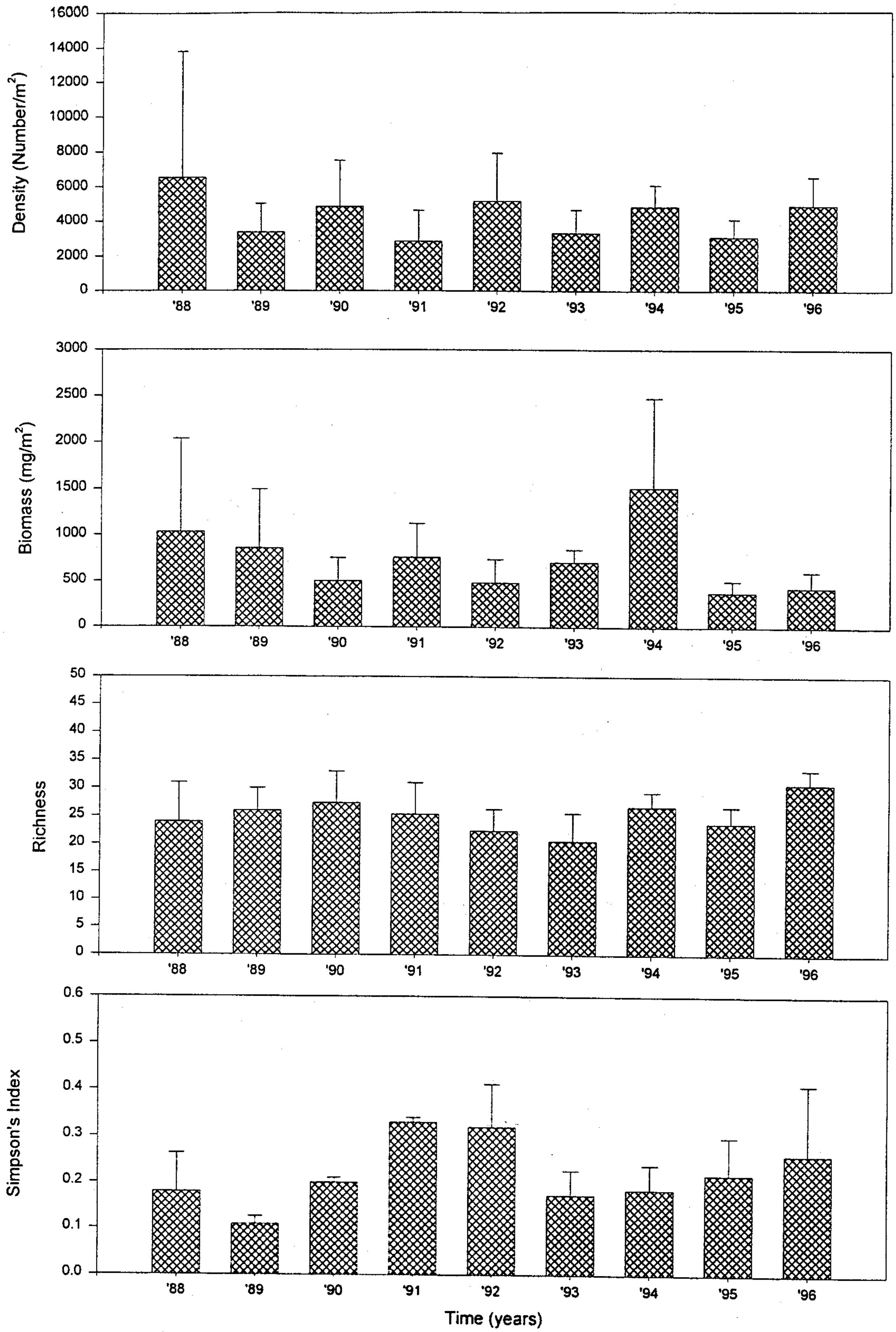


Figure 10. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cliff Creek. Error bars equal +1SD from the mean, n=5.

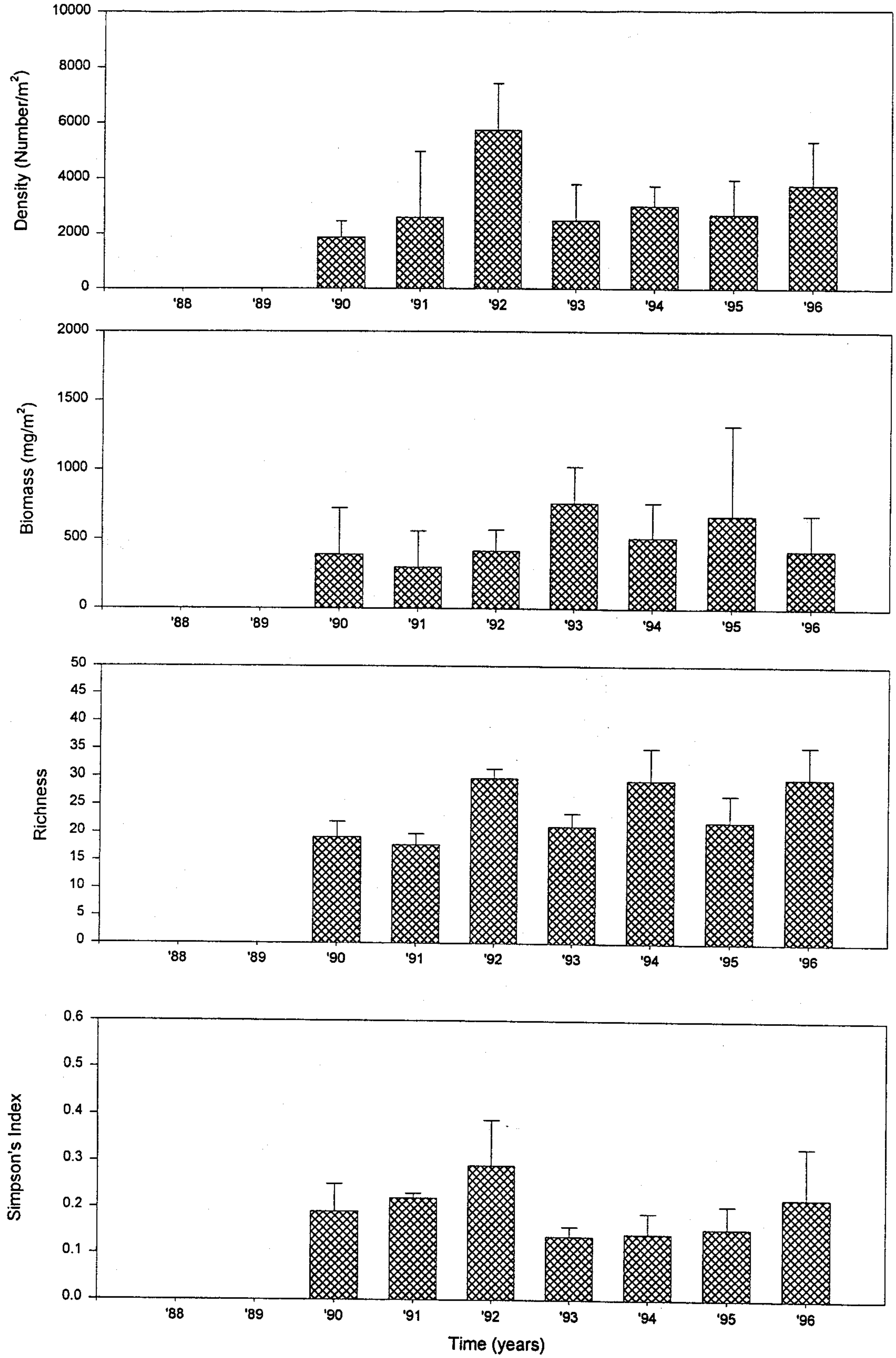


Figure 11. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Cougar Creek. Error bars equal +1SD from the mean, n=5.

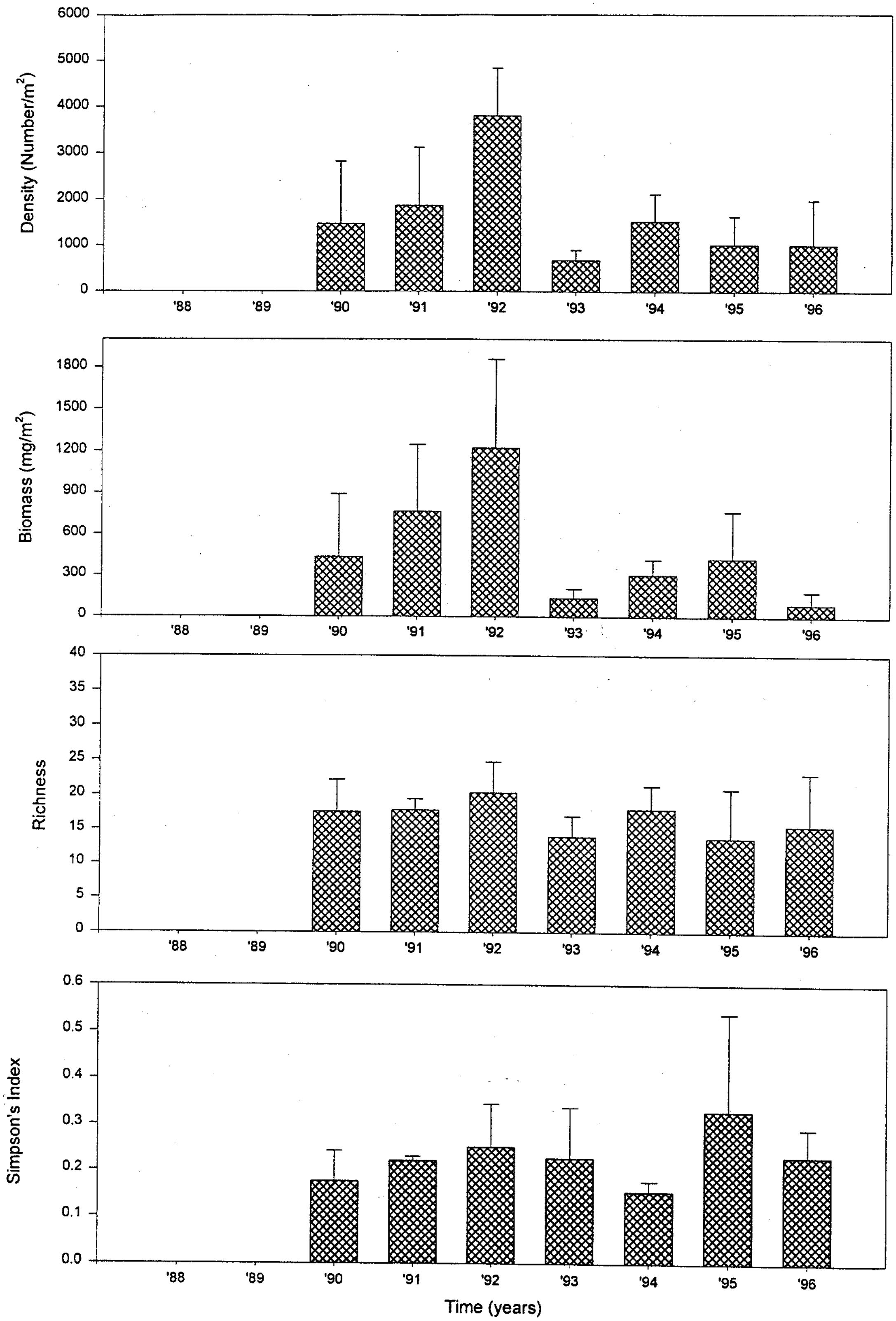


Figure 12. Macroinvertebrate density, biomass, taxa richness and Simpson's Index for Goat Creek. Error bars equal +1SD from the mean, n=5.

Table 6. Relative abundance ot the 15 most common macroinvertebrate taxa found in the study streams in 1996. SD=one standard deviation from the mean, n=5.

Rush

	mean	SD
Oligochaeta	0.25	0.19
Chironomidae	0.17	0.11
Hydracarina	0.11	0.05
Baetis tricaudatus	0.09	0.08
Acentrella	0.06	0.03
Optioservus	0.04	0.02
Serratella tibialis	0.03	0.02
Baetis bicaudatus	0.03	0.03
Sweltsa	0.03	0.01
Nemoura	0.03	0.04
Cinygmula	0.03	0.01
Epeorus longimanus	0.01	0.01
Perlodidae	0.01	0.01
Zapada	0.01	0.01
Ameletus cooki	0.01	0.02

Cave

	mean	SD
Oligochaeta	0.58	0.06
Hydracarina	0.09	0.03
Heterlimnius	0.08	0.03
Chironomidae	0.04	0.02
Baetis bicaudatus	0.03	0.03
Sweltsa	0.02	0.01
Baetis tricaudatus	0.02	0.01
Doroneuria	0.02	0.01
Serratella tibialis	0.01	0.02
Zapada	0.01	0.01
Cinygmula	0.01	0.00
Acentrella	0.01	0.01
Ostracoda	0.01	0.01
Paraleptophlebia heteronea	0.01	0.00
Ameletus cooki	0.01	0.01

Pioneer

	mean	SD
Oligochaeta	0.55	0.25
Rhithrogena robusta	0.08	0.08
Nemouridae	0.04	0.03
Sweltsa	0.04	0.01
Cinygmula	0.03	0.02
Heterlimnius	0.03	0.01
Doroneuria	0.03	0.02
Baetis bicaudatus	0.03	0.03
Chironomidae	0.03	0.02
Ostracoda	0.02	0.02
Zapada	0.02	0.01
Capniidae	0.02	0.01
Rhyacophila vagrita	0.02	0.01
Hydracarina	0.01	0.01
Epeorus grandis	0.01	0.01

Cliff

	mean	SD
Oligochaeta	0.40	0.23
Rhithrogena robusta	0.10	0.07
Nemouridae	0.09	0.09
Cinygmula	0.07	0.03
Baetis bicaudatus	0.04	0.04
Zapada	0.04	0.03
Epeorus	0.03	0.01
Sweltsa	0.03	0.02
Heterlimnius	0.02	0.01
Chironomidae	0.02	0.01
Rhyacophila acropedes	0.02	0.02
Serratella tibialis	0.02	0.02
Baetis tricaudatus	0.02	0.02
Drunella doddsi	0.01	0.01
Dolophilodes	0.01	0.01

Cougar

	mean	SD
Oligochaeta	0.41	0.12
Baetis bicaudatus	0.10	0.05
Nemouridae	0.06	0.04
Chironomidae	0.06	0.02
Heterlimnius	0.05	0.01
Zapada	0.04	0.02
Cinygmula	0.04	0.02
Rhithrogena robusta	0.04	0.05
Hydracarina	0.02	0.01
Turbellaria	0.02	0.04
Ostracoda	0.02	0.02
Baetis tricaudatus	0.01	0.01
Epeorus grandis	0.01	0.01
Epeorus longimanus	0.01	0.01
Paraleptophlebia memorialis	0.01	0.01

Goat

	mean	SD
Chironomidae	0.31	0.12
Heterlimnius	0.15	0.20
Zapada	0.12	0.08
Hydracarina	0.10	0.08
Cleptelmis	0.05	0.07
Stenus	0.03	0.04
Muscidae	0.02	0.03
Dixa	0.02	0.03
Oligochaeta	0.02	0.02
Simulium	0.01	0.02
Suwallia	0.01	0.02
Sweltsa	0.01	0.02
Epeorus longimanus	0.01	0.02
Baetis bicaudatus	0.01	0.01
Zapada cinctipes	0.01	0.01

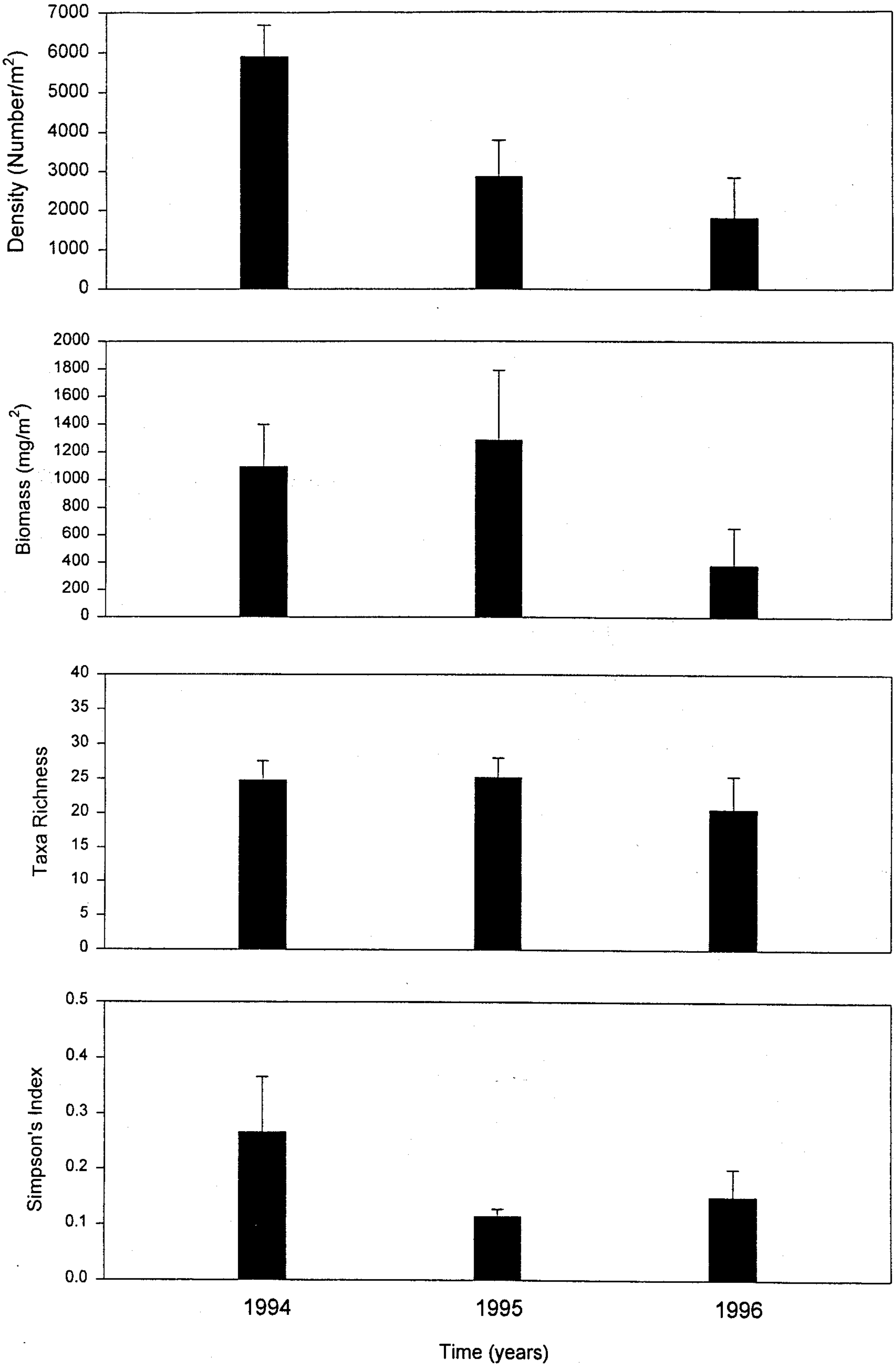


Figure 13. Mean values of macroinvertebrate density, biomass, taxa richness and Simpson's Index for Upper Cliff Creek, 1994-1996. Error bars equal +1SD from the mean, n=5.

Table 7. Relative abundance of the 15 most common macroinvertebrate taxa in Upper Cliff Creek. 1994-1996. SD=one standard deviation from the mean, n=5.

1994	mean	SD
Oligochaeta	0.47	0.12
Baetis bicaudatus	0.13	0.05
Chironomidae	0.07	0.01
Neothremma	0.05	0.03
Yoroperla brevis	0.03	0.01
Glossosoma	0.03	0.01
Arctopsyche	0.03	0.01
Serratella tibalis	0.02	0.02
Zapada	0.02	0.02
Rhyacophila vagrita	0.02	0.01
Turbellaria	0.02	0.01
Cinygmula	0.01	0.01
Drunella coloradensis	0.01	0.01
Rhithrogena robusta	0.01	0.02
Epeorus longimanus	0.01	0.01

1995	mean	SD
Chironomidae	0.22	0.05
Oligochaeta	0.16	0.06
Epeorus deceptivus	0.08	0.03
Baetis bicaudatus	0.08	0.02
Yoroperla brevis	0.06	0.03
Drunella doddsi	0.05	0.03
Polycentropus	0.05	0.03
Drunella coloradensis	0.05	0.02
Suwallia sp.	0.04	0.03
Neothremma	0.03	0.02
Cinygmula	0.03	0.02
Megarcys	0.02	0.01
Paraleuctra	0.02	0.02
Zapada	0.02	0.01
Rhyacophila vagrita	0.01	0.01

1996	mean	SD
Baetis bicaudatus	0.23	0.09
Cinygmula	0.09	0.08
Chironomidae	0.08	0.05
Sweltsa	0.06	0.04
Neothremma	0.05	0.08
Epeorus	0.05	0.04
Rhyacophila vepulsa	0.04	0.03
Drunella doddsi	0.03	0.03
Epeorus deceptivus	0.03	0.04
Drunella coloradensis	0.03	0.03
Yoraperla brevis	0.03	0.02
Zapada	0.02	0.04
Rhyacophila vagrita	0.02	0.02
Turbellaria	0.01	0.03
Hycracarina	0.01	0.02

South Fork of the Salmon River Tributaries

Only minor changes have been observed in the measured water chemistry variables in Circle End, Tailholt, and Fritser Creeks (Table 8). Circle End and Tailholt are considerably more alkaline than is Fritser. For example, specific conductance is 5-6 fold greater and alkalinity 3-4 fold greater in Circle End and Tailholt than in Fritser. Physical habitat measures have not shown substantial change over the course of the study (Table 8), despite extremely high flows during a rain on snow event in March 1996 (T.V. Royer, personal observation).

The extremely small size of the streams in the salvage area precluded standard channel surveys, except for the reference stream, Smith Creek. In addition, the streams often flowed through talus and lacked defined channels. Trail crossings provided access for collection of water samples. In two of the streams, Big Flat Creek and K Creek, we were able to collect qualitative samples of the invertebrate community by disturbing an undefined area upstream of a Surber. A smaller device will be employed for future surveys in these streams to allow quantitative sampling. Among the sites in the salvage logging area, conductance and alkalinity varied considerably, with Smith Creek the least alkaline and Little Flat Creek the most alkaline (Table 8).

Algal standing crop increased in Circle End from 1995 to 1996, but did not change in Tailholt or Fritser over the same time period (Fig. 14). Mean values ranged from approximately 8 mg/m^2 in Tailholt to 13 mg/m^2 in Circle End and Fritser. Mean chlorophyll-a in Smith Creek was approximately 7 mg/m^2. For all sites, periphyton AFDM displayed the same pattern as that for chlorophyll-a (Fig. 14).

Estimates of invertebrate density and biomass in Circle End, Tailholt, and Fritser have shown large variability within the replicate samples. This likely reflects the large amount of habitat heterogeneity in these small, steep streams. Mean density in Circle End increased from approximately 2,000 individuals per m^2 in 1995 to 5,000 individuals per m^2 in 1996 (Fig. 15). Tailholt showed an opposite trend, with density declining by 50% from 1995 to 1996, while invertebrate density in Fritser remained essentially unchanged. For all three sites, invertebrate biomass displayed the same pattern as density (Fig. 15). Density in Smith Creek was approximately 7,000 individuals per m^2 and biomass about 1,400 mg/m^2.

Table 8. Habitat and chemical characteristics of the South Fork Salmon River tributaries, 1994-96. SD=one standard deviation from the mean, CV=coefficient of variation

	Circle End	Tailholt	Fritser	Smith	Little Flat	Big Flat	China	K
Discharge (m3/s)								
1994	0.009	0.02						
1995	0.013	0.06	0.27					
1996	0.014	0.07	0.42	0.12				
Conductance (uS/cm @ 25C)								
1994	186	143						
1995	149	108	27					
1996	129	76		54	185	102	129	90
Alkalinity (mg CaCO3/l)								
1995	52	30	10					
1996	40	28	10	16	44	24	28	44
Hardness (mg CaCO3/l)								
1995	68	56	28					
1996	65	53	20	44	92.9	57	61	40

	Circle End			Tailholt			Fritser			Smith		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Stream Width (cm)												
1994	68	17	0.25	116	22	0.19						
1995	117	40	0.34	169	24	0.14	283	43	0.15			
1996	128	54	0.43	168	64	0.38	238	88	0.37	316	32	0.10
Stream Depth (cm)												
1994	4	3	0.81	10	5	0.51						
1995	5	5	1.13	19	11	0.57	26	19	0.74			
1996	7	6	0.86	15	9	0.60	18	12	0.67	17	9	0.53
Substrata Size (cm)												
1994	14	39	2.89	13	30	2.35						
1995	30	27	0.89	20	30	1.47	42	36	0.84			
1996	19	44	2.32	13	30	2.31	23	38	1.65	13	11	0.85
Substrata Embeddedness (%)												
1994	38	45	1.16	23	33	1.46						
1995	64	29	0.46	76	30	0.39	55	33	0.60			
1996	58	42	0.72	72	37	0.51	58	39	0.67	51	39	0.76

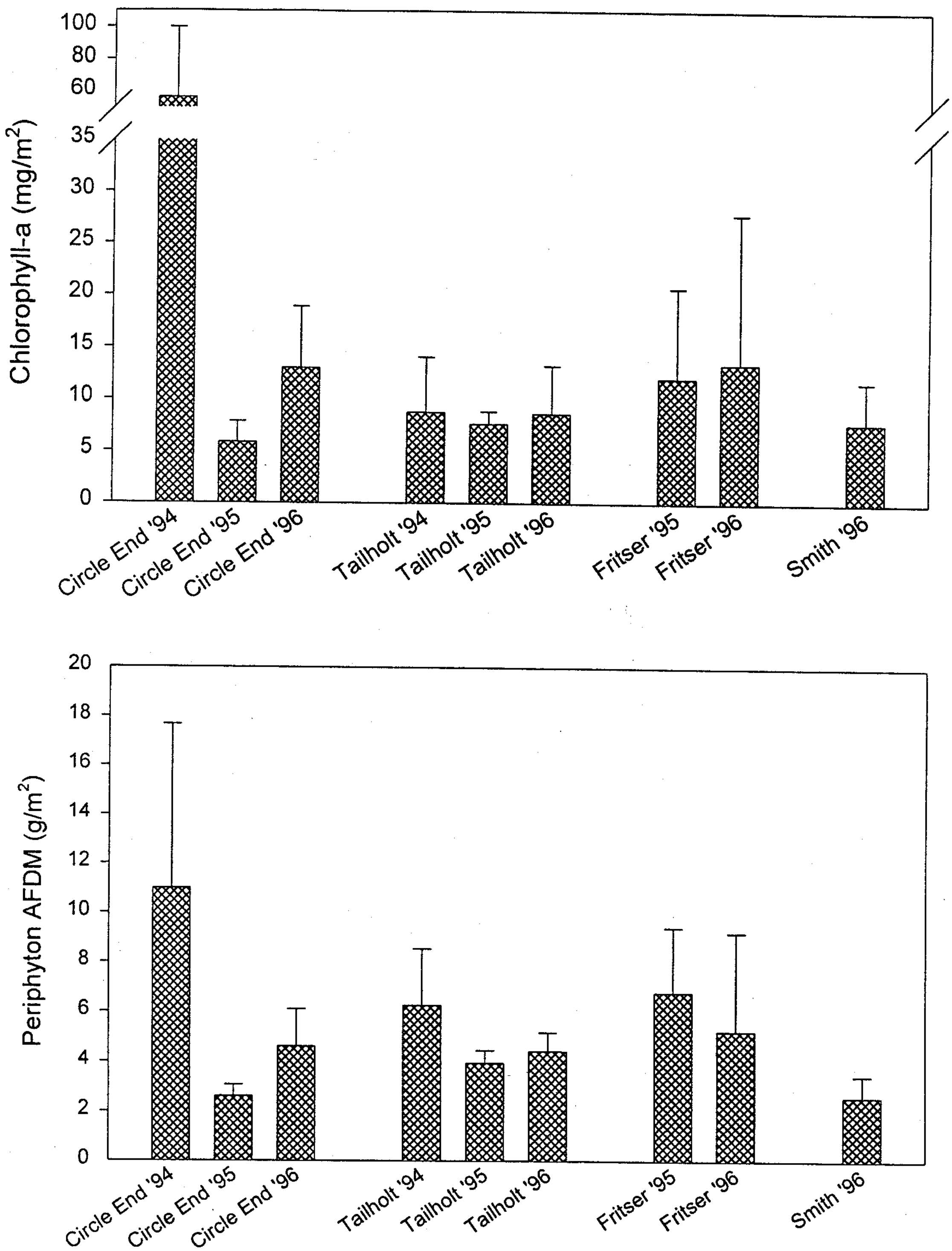
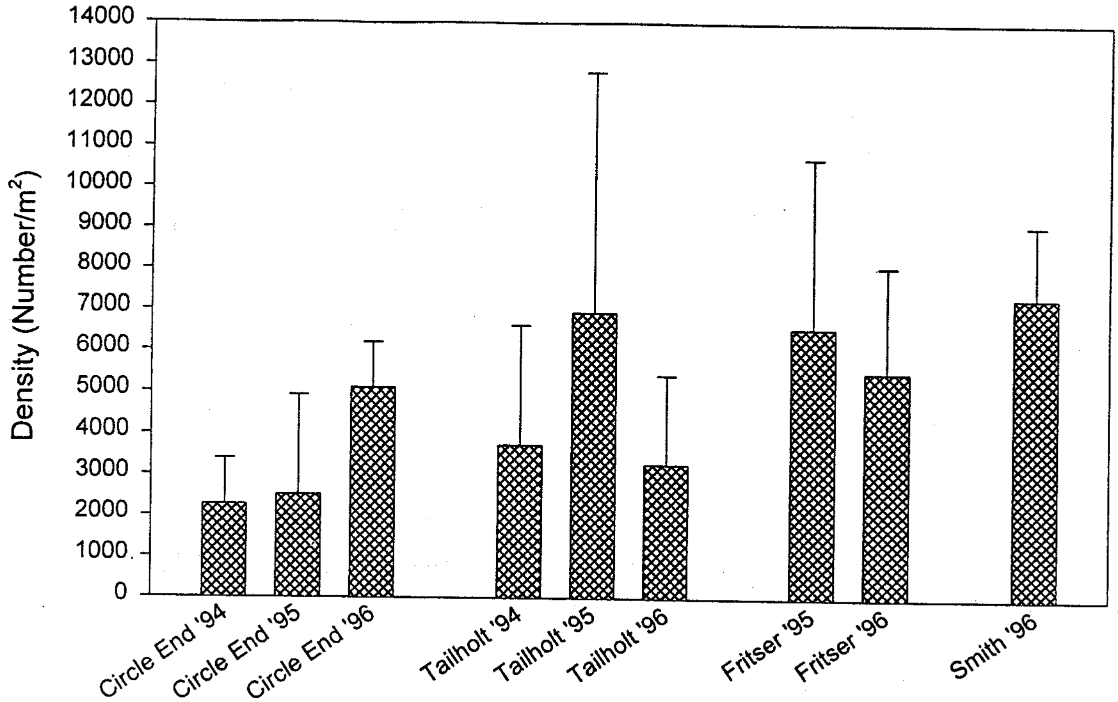


Figure 14. Mean values of periphyton chlorophyll *a* and ash-free dry mass (AFDM) in each stream, 1994-1996. Error bars equal +1SD, n=5.



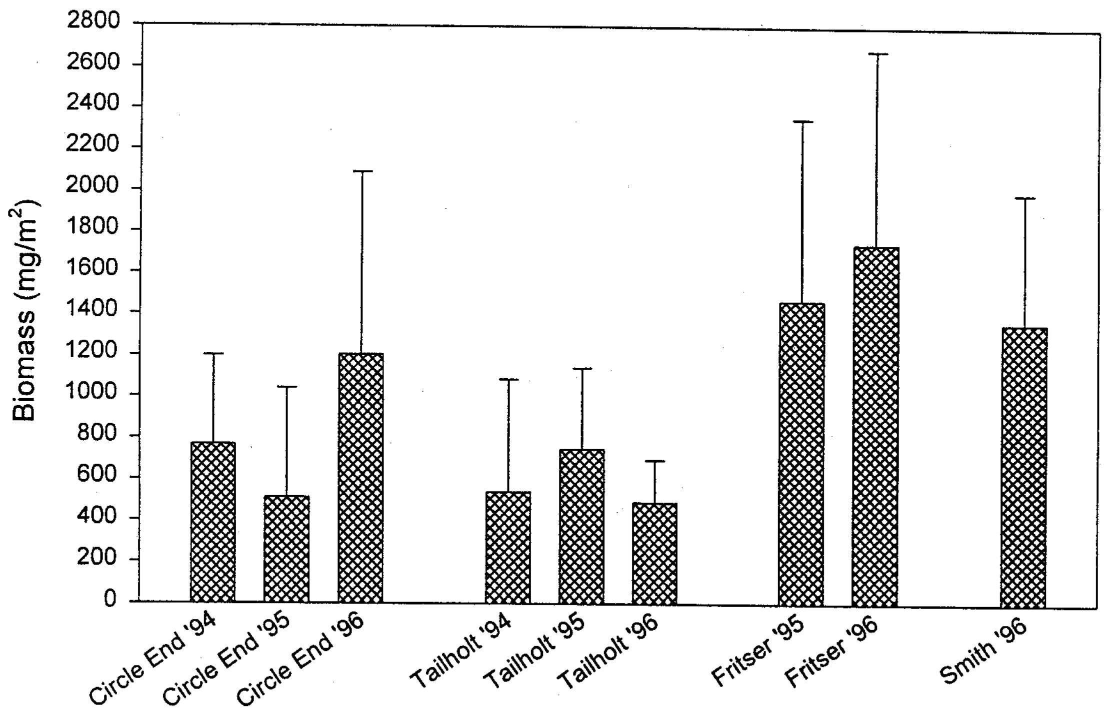


Figure 15. Mean values of macroinvertebrate density and biomass for each stream, 1994-1996. Error bars equal +1SD from the mean, n=5.

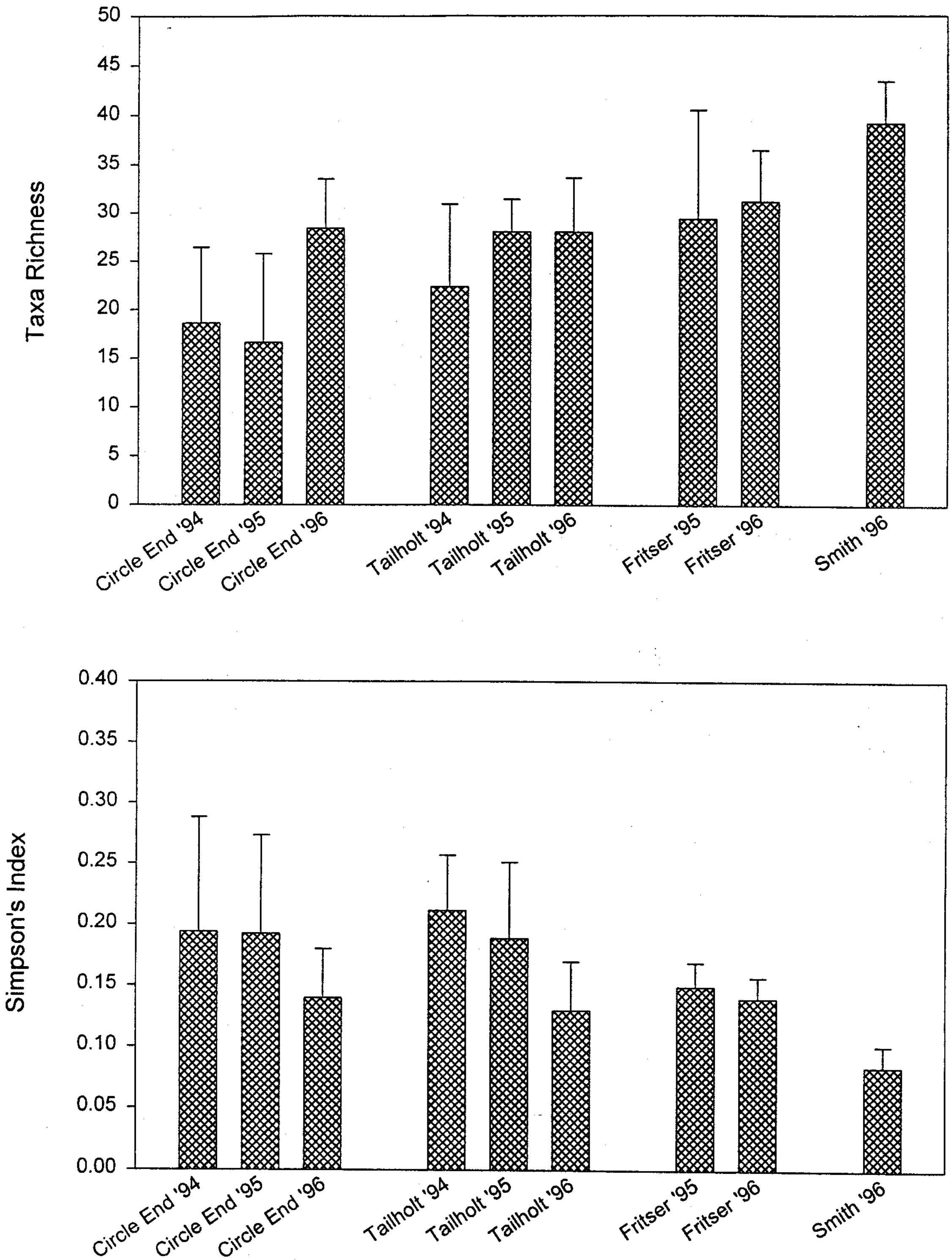


Figure 16. Mean values of macroinvertebrate taxa richness and Simpson's Index for each stream, 1994-1996. Error bars equal +1SD from the mean, n=5.

Table 9. Relative abundance of the 15 most common macroinvertebrate taxa from each stream in 1996. SD=one standard deviation from the mean, n=5.

Circle End

	mean	SD
Cleptelmis	0.28	0.16
Turbellaria	0.17	0.12
Baetis bicaudatus	0.09	0.07
Empididae	0.09	0.16
Paraleptophlebia heteronea	0.07	0.07
Yoroperla brevis	0.06	0.02
Chironomidae	0.05	0.01
Oligochaeta	0.03	0.02
Sweltsa	0.02	0.02
Zapada	0.02	0.01
Hydracarina	0.02	0.02
Baetis tricaudatus	0.02	0.01
Isoperla	0.02	0.02
Cinygmula	0.02	0.01
Ephemerella inermis	0.01	0.02

Tailholt

	mean	SD
Cleptelmis	0.18	0.22
Baetis bicaudatus	0.16	0.07
Oligochaeta	0.13	0.11
Yoroperla brevis	0.11	0.04
Heterlimnius	0.1	0.07
Chironomidae	0.08	0.02
Cinygmula	0.05	0.05
Turbellaria	0.04	0.03
Sweltsa	0.03	0.02
Zapada	0.03	0.04
Ephemerella inermis	0.02	0.02
Neothremma	0.01	0.01
Rhyacophila vagrita	0.01	0.01
Baetis tricaudatus	0.01	0.01
Drunella spinifera	0.01	0.01

Fritser

	mean	SD
Chironomidae	0.36	0.11
Baetis bicaudatus	0.16	0.08
Cleptelmis	0.09	0.04
Caudatella	0.09	0.05
Epeorus grandis	0.08	0.05
Heterlimnius	0.04	0.04
Baetis tricaudatus	0.04	0.01
Zapada	0.03	0.01
Yoroperla brevis	0.03	0.02
Drunella coloradensis	0.02	0.01
Hydracarina	0.02	0.02
Polycentropus	0.02	0.02
Drunella spinifera	0.01	0.01
Sweltsa	0.01	0.01
Oligochaeta	0.01	0.01

Smith

	mean	SD
Oligochaeta	0.17	0.11
Baetis bicaudatus	0.1	0.05
Baetis tricaudatus	0.09	0.01
Heterlimnius	0.07	0.04
Drunella doddsi	0.06	0.02
Chironomidae	0.06	0.01
Arctopsyche grandis	0.05	0.02
Caudatella	0.05	0.03
Yoroperla brevis	0.04	0.02
Cleptelmis	0.04	0.02
Zapada	0.03	0.03
Hydracarina	0.03	0.02
Ephemerella inermis	0.02	0.02
Cinygmula	0.02	0.02
Sweltsa	0.02	0.01

Table 10. Macroinvertebrate taxa found in K Creek during August 1996.

Ephemeroptera
- Ameletidae
  - *Ameletus similor*
- Baetidae
  - *Baetis bicaudatus*
  - *Baetis tricaudatus*
- Ephemerellidae
  - *Caudatella sp.*
  - *Drunella coloradensis*
  - *Drunella doddsi*
  - *Drunella spinifera*
  - *Serratella tibialis*
- Heptageniidae
  - *Cinygmula sp.*
  - *Epeorus grandis*
  - *Epeorus longimanus*
- Leptophlebiidae
  - unidentified (too small)

Plecoptera
- Chloroperlidae
  - *Kathroperla sp.*
  - *Sweltsa sp.*
- Leuctridae
  - unidentified (too small)
- Nemouridae
  - *Visoka cataractae*
  - *Zapada sp.*
- Peltoperlidae
  - *Yoraperla brevis*
- Perlidae
  - *Doroneuria sp.*
- Perlodidae
  - *Isoperla sp.*
  - *Megarcys sp.*
  - *Setvena sp.*

Trichoptera
- Brachycentridae
  - *Micrasema sp.*
- Hydropsychidae
  - *Parapsyche sp.*

Table 10 continued.

Trichoptera continued
Lepidostomatidae
Lepidostoma sp.
Rhyacophilidae
Rhyacophila acropedes
Rhyacophila hyalinata

Diptera
Chironomidae sp.
Empididae
Clinocera sp.
Unidentified sp.
Pelecorhynchidae
Glutops sp.
Psychodidae
Maruina sp.
Pericoma sp.
Simuliidae
Prosimulium sp.
Simulium sp.
Tipulidae
Dicranota sp.

Coleoptera
Elmidae
Cleptelmis sp.
Heterlimnius sp.
Lara sp.
Narpus sp.
Staphylinidae
Stenus sp.

Hymenoptera
Diapriidae

Collembola
Hydracarina
Nematoda
Oligochaeta
Ostracoda

Table 11. Macroinvertebrate taxa found in Big Flat Creek during August 1996.

Ephemeroptera
- Baetidae
  - *Baetis bicaudatus*
  - *Baetis tricaudatus*
- Ephemerellidae
  - *Attenella sp.*
  - *Caudatella hystrix*
  - *Drunella coloradensis*
  - *Drunella doddsi*
  - *Drunella spinifera*
  - *Serratella tibialis*
- Heptageniidae
  - *Cinygmula sp.*
  - *Epeorus grandis*
  - Unidentified (early instars)
- Leptophlebiidae
  - Unidentified (early instars)

Plecoptera
- Chloroperlidae
  - *Sweltsa sp.*
- Leuctridae
  - unidentified (too small)
- Nemouridae
  - *Amphinemura sp.*
  - *Visoka cataractae*
  - *Zapada sp.*
  - *Zapada cincitipes*
- Peltoperlidae
  - *Yoraperla brevis*
- Perlidae
  - *Doroneuria sp.*
- Perlodidae
  - *Isoperla sp.*

Trichoptera
- Brachycentridae
  - *Micrasema sp.*
- Glossosomatidae
  - *Glossosoma sp.*

Table 11 continued.

Trichoptera continued

Hydropsychidae

Parapsyche elsis

Unidentified (early instars)

Rhyacophilidae

Rhyacophila acropedes

Rhyacophila vepulsa

Uenoidae

Neophylax sp.

Diptera

Ceratopogonidae

Chironomidae

Pelecorhynchidae

Glutops sp.

Simuliidae

Simulium sp.

Thaumaleidae

Tipulidae

Dicranota sp.

Unidentified sp.

Coleoptera

Elmidae

Heterlimnius sp.

Narpus sp.

Hydracarina
Nematoda
Turbellaria
Oligochaeta
Ostracoda

Mean taxa richness was greatest in Smith Creek with 37 taxa (Fig. 16). Taxa richness was basically unchanged from 1995 to 1996 in Tailholt (approx. 27 taxa) and Fritser (approx. 30 taxa), whereas Circle End displayed an increase from 15 taxa in 1995 to approximately 27 taxa in 1996. Simpson's Index declined slightly in Circle End and Tailholt from 1995 to 1996, but was unchanged in Fritser. All measures of Simpson's Index over the course of the study have been below 0.20, suggesting very diverse invertebrate communities in these streams. In particular, Smith Creek displayed an extremely diverse benthic community, with nearly 40 taxa and a value for Simpson's Index below 0.10 (Fig. 16).

Table 9 presents the relative abundance of the 15 most common taxa found in each stream in 1996. Chironomidae, Oligochaeta, Turbellaria, *Baetis*, and *Cleptelmis* (Coleoptera: Elmidae), were generally the most abundant taxa in Circle End, Tailholt, Fritser, and Smith Creeks. The list of taxa found in the qualitative samples collected from K Creek and Big Flat Creek are shown in Tables 10 and 11, respectively. Forty-six taxa were identified from K Creek and 39 from Big Flat Creek.

DISCUSSION

Royer and Minshall (1996) concluded that chemical and physical conditions in Cliff, Cougar, and Goat had not been altered due to the Golden Fire of 1988. It was hypothesized that these streams might, however, respond differently to the floods during the spring of 1996 than would the unburned streams (Royer and Minshall 1996). Our research during the summer of 1996 showed only minor evidence that the burned streams were scoured to a greater extent than were the unburned streams. Mean stream width in 1996 was slightly greater in Cliff and Cougar than had been measured previously (see Table 4) and might indicate scouring of the channels in these systems. However, the average substrate size was not altered, as might be expected following severe flooding.

Circle End, Tailholt, and Fritser Creeks also experienced severe flooding in the spring of 1996, but major channel alterations were not measured during our survey of these sites. Minshall et al. (1995) reported unstable benthic habitat in streams of Yellowstone National Park as a result of the 1988 fires. Pre-fire data are not available for Fritser, however it does not appear that the Chicken Fire created an unstable channel in that stream. Similarly, it appears that the Golden Fire has not, to date, been a major influence on the physical and chemical habitat of Cliff, Cougar, or Goat Creeks. The more arid environment and less-vegetated slopes in the Payette National Forest, relative to Yellowstone, may explain the different response to wildfire seen in streams in the two areas.

Water temperature is a critical component of stream habitat, and is largely responsible for developmental rates of aquatic invertebrates (e.g., Vannote and Sweeney 1980, Ward and Standford 1982). The Chicken Fire has created warmer and more variable thermal conditions in Fritser, Pidgeon, and Grave Creeks, relative to conditions in Tailholt and Circle End (Royer and Minshall 1997). This result does not appear to hold for streams burned by the Golden Fire, however. For example, Upper Cliff Creek, which was within the fire perimeter, was colder than was Lower Cliff, which was outside the fire perimeter (see Figs. 3 and 4). This suggests that one or more factors, such as elevation or groundwater input, is showing a greater influence than is solar radiation. Groundwater inputs can have a strong control on stream temperatures (Smith and Lavis 1975) and, it appears, may override the effect of increased solar radiation following a wildfire. In general, neither the Chicken or Golden Fires have resulted in stream temperatures that are unsuitable for cold water biota.

The severity a given disturbance has on the ecological conditions of a stream ecosystem can be gaged by determining if the event resulted in conditions outside the normally observed range of variability. In this regard, one goal of this research is to define the natural range of variability that occurs in wilderness streams. The abundance and diversity of aquatic macroinvertebrates provides an ecological assessment for each of the study streams. Repeated sampling of the systems allows for determination of the long-term mean and the variability around that mean for particular variables. For study streams in the Big Creek catchment, density tends to vary around a long-term mean of 4,000 to 5,000 individuals per m^2 (see Figs 7-12). Taxa richness is, in part, a function of stream size (Minshall et al. 1985), and this can be seen in the long-term mean taxa richness for Rush Creek versus Cliff Creek and Cougar Creek. Rush, the largest stream, typically has about 30 taxa, whereas Cliff and Cougar (both smaller than Rush) have about 25 taxa. This difference is not large, but it is consistent over 7-9 years of study. Long-term trends such as these provide important assessment tools for resource managers.

The direct relationship between stream size and number of invertebrate taxa also was observed in the SF Salmon tributaries, although the temporal scale of sampling is not as great as in Big Creek. Smith Creek, the largest stream sampled along the SF Salmon, contained nearly 40 invertebrate taxa, whereas Circle End, the smallest stream, generally contains about half that number (see Fig. 16). In general, taxa richness appeared to be similar between the Big Creek and SF Salmon sites, as well as other sites in the Frank Church Wilderness (e.g., Richards and Minshall 1992). Taxa richness also was the most temporally stable community variable measured in streams from either location.

The spatial and temporal consistency observed in taxa richness suggests it may be an excellent metric for determining if perturbations have occurred in a given stream, and if so, the severity of the impact. Thus, future sampling of Big Flat Creek and K Creek should reveal changes in the kinds and number taxa found in those systems if the streams are degraded by the salvage logging.

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LITERATURE CITED

American Public Health Association. 1992. Standard methods for the examination of water and wastewater. APHA, New York.

Bevenger, G.S. and R.M. King. 1995. A pebble count procedure for assessing watershed cumulative effects. USDA Forest Service Research Paper RM-RP-319, Fort Collins, Co.

Bovee, K.D. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and techniques. Cooperative Instream Flow Service Group, Western Energy and Land Use Team, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Buchanan, T.J. and W.P. Somers. 1969. Discharge measurements of gaging stations. In: Techniques of Water Resources Investigations. Book 3, Chapter A8. U.S. Geol. Survey.

Davis, J.C., G.W. Minshall, and C.T. Robinson. *In review.* Monitoring wilderness stream ecosystems. Aldo Leopold Wilderness Research Center, USFS, Missoula.

Greeson, P.E., T.A. Ehlke, G.A. Irwin, B.W. Lium, and K.V. Slack (eds). 1977. Methods for collection and analysis of aquatic biological and microbiological samples. Techniques of Water-Resources Investigations. U.S. Geol. Surv. 322 p.

Lind, O.T. 1979. Handbook of common methods in limnology. 2nd edition. C. V. Mosby Co., St. Louis 199 p.

Merritt, R.W. and K.W. Cummins (eds). 1995. An introduction to the aquatic insects. 3rd edition. Kendall/Hunt Publishing Co., Dubuque, Iowa 862 p.

Minshall, G.W., C.T. Robinson, T.V. Royer, and S.R. Rushforth. 1995. Benthic community structure in two adjacent streams in Yellowstone National Park five years after the 1988 wildfires. Great Basin Naturalist 55:193-200.

Minshall, G.W., R.C. Petersen, and C.F. Nimz. 1985. Species richness in streams of different size from the same drainage. American Naturalist 125:16-38.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service General Technical Report INT-138 70 p.

Richards, C. and G.W. Minshall. 1992. Spatial and temporal trends in stream macroinvertebrate communities: the influence of catchment disturbance. Hydrobiologia 241:173-184.

Robinson, C.T. and G.W. Minshall. 1986. Effects of disturbance frequency on stream benthic community structure in relation to canopy and season. Journal of the North American Benthological Society 5:237-248.

Royer, T.V. and G.W. Minshall. 1997. Temperature patterns in small streams following wildfire. Archive für Hydrobiologia 140:237-242.

Royer, T.V. and G.W. Minshall. 1996. Habitat and biotic conditions during 1995 in streams influenced by wildfire. Dept. Bio. Sci., Idaho State Univ. 46 p.

Royer, T.V., C.T. Robinson, and G.W. Minshall. 1995. Influence of wildfire on selected streams in the Payette National Forest. Dept. Bio. Sci., Idaho State Univ. 35 p.

Smith, K. and M.E. Lavis. 1975. Environmental influences on the temperature of a small upland stream. Oikos 26:228-236.

Stednik, J.D. 1991. Wildland water quality sampling and analysis. Academic Press, New York.

USFS. 1995. Tailholt Administrative Research Study, Record of Decision for the Final Environmental Impact Statement. Payette National Forest 22 p.

Vannote, R.L. and B.W. Sweeney. 1980. Geographic analysis of thermal equilibria: a conceptual model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. American Naturalist 115:667-695.

Ward, J.V. and J.A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Annual Review of Entomology 27:97-117.

Weber, C.I. (ed.) 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA-670/ 4-73-001 U.S. EPA, Cincinnati 53 p.